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The American Heart Journal

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Original Communications

THE SELECTION OF CASES OF THROMBO-ANGIITIS OBLITERANS AND OTHER CIRCULATORY DISEASES OF THE EXTREMITIES FOR SYMPATHETIC GANGLIONECTOMY*

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THE application of sympathetic ganglionectomy to selected types of disease of the peripheral arteries has marked a distinct advance in their treatment. Evaluation of this operation over a period of eight years has demonstrated conclusively a maintained and permanent vasodilatation of the peripheral arteries. In cases of spastic paraplegia, arthritis, and uncomplicated forms of Raynaud's disease, which are diseases without obliterative lesions in the arteries, vasodilatation is maintained at maximal levels as measured by thermometric and calorimetric methods.[5] In diseases with occlusive lesions of the arteries of the extremities vasodilatation is maximal and permanent, provided the process of thrombosis is not progressive. The rationale of employing sympathetic ganglionectomy in diseases with occlusive lesions is based on the demonstration of high degrees of vasoconstriction in the nonoccluded major and collateral vessels. The diminished circulation in these diseases is the direct effect of two factors: (1) recurrent segmental occlusion of the arteries by thromboses, and (2) abnormal vasoconstriction in the nonoccluded arteries in the primary and collateral circulation. Vasoconstriction is measured indirectly by variations of the surface temperature of the acral areas. In occlusive arterial diseases the surface temperatures of the digits are usually low; that is, varying

*Read before the American Academy of Orthopedic Surgeons, Chicago, January 8, 1934.

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between 22° and 27° C. As a result of a high environmental temperature, increases in the surface temperature are noted, but the range of fluctuation is restricted.

Recognition of the fact that both the obstructive and the vasomotor components contribute to the diminished circulation is important, as it provides an adequate explanation for the efficacy of sympathetic ganglionectomy in selected cases. Mulvihill and Harvey have shown that with ligation of the femoral arteries in the experimental animal the collateral circulation, as measured by the surface temperature, slowly returns to its preoperative level. If at the time of ligation the lumbar sympathetic ganglia are removed, recovery of the circulation is fairly complete within a period of twenty-four hours. The work of Baldes, Herrick, and Essex on dogs demonstrated that the flow of blood through the larger arteries, as measured by the Thermo-Stromuhr method of Reiss, was increased as much as 100 per cent on the side on which unilateral sympathetic ganglionectomy was performed.

The usefulness of sympathetic ganglionectomy in cases of occlusive diseases of the arteries has rested largely on the proper selection of those cases, and it was realized early that it would be futile to attempt to operate in all of them. In the older patients afflicted with arteriosclerosis obliterans the range of vasomotor activity is narrow, and the development of collateral circulation is less adequate (Horton) than in younger patients afflicted with thrombo-angiitis obliterans. Among these older patients also there is a greater operative mortality, as in many of them arteriosclerotic lesions of coronary, cerebral, and renal arteries are present.

THE VASOCONSTRICTION COMPONENT

Methods used.—Various methods have been employed to determine the amount of vasoconstriction present in the limbs. In 1926, one of us (Brown) described the use of nonspecific fever as a vasodilating agent. Fever is a most effective means of producing high degrees of vasodilatation. Foreign protein (Lederle's triple typhoid vaccine) is injected intravenously, and the temperature of the mouth and the surface temperatures of the digits of the extremities are measured every thirty minutes during the phase of fever. The procedure in detail, as we have carried it out at the Mayo Clinic, has been as follows: A room with constant temperature is used, with a range of environmental temperature controlled between 24° and 26° C. Thermocouples are applied to the various digits, and the readings are taken every ten minutes until a basal or constant level is obtained. Triple typhoid vaccine is injected intravenously in doses of 5 to 25 million killed organisms, depending on the size and sex of the patient. The following data are obtained: (1) the increase in the temperature of the mouth, (2) the increase in the surface temperature of the digits, and (3) the maximal vasodilatation level.

From these values three points are noted: (a) The vasomotor index (V. I.). (To determine this, the rise of surface temperature is divided by the rise in temperature of the mouth or blood, and the result represents the increase in surface temperature for each degree rise in the temperature of the mouth or blood. A vasomotor index of 2 or more is considered to indicate an abnormal degree of vasoconstriction.) (b) The vasomotor range (V. R.). (This is the rise in the surface temperature of the affected digits from basal to maximal levels with fever. A high degree of vasoconstriction is considered to be present if this increase is at least 4° C. or more.) (c) The maximal vasodilatation level (M. V. L.). (This is the highest temperature obtained in the affected digits. If it attains a level of 30° C. or more, a degree of vasodilatation adequate to justify operation is considered to be present in the affected digit.) In all the foregoing calculations the rise in the temperature of the mouth is deducted from the rise in surface temperature, so as to eliminate the actual increase in the temperature of the blood.

Morton and Scott have reported the use of general, local, and spinal anesthesia to obtain vasodilatation. These are satisfactory methods when the facilities are such that they can be employed as a routine procedure. Morton and Scott have postulated a "normal vasodilatation level" of 33° C., and the difference between this and the value obtained they have designated as the "obstruction index." White has employed injection anesthesia of peripheral nerves to prognosticate the effects of sympathectomy. Lewis and Coller and Maddock have used increased environmental heat, and Landis has suggested the immersion of both arms in water at 45° C. for a period of at least thirty minutes, which is followed by vasodilatation of the feet. We have studied the effects of various vasodilating drugs, including ethyl alcohol, given by mouth,[8] acetylcholine,[10] and theobromine,[15] also those of hot drinks and increased environmental temperature. With all of them variable degrees of vasodilatation have been obtained. None of the procedures has produced the maximal dilatation responses comparable to those produced by fever or anesthesia.

SELECTION OF CASES OF THROMBO-ANGIITIS OBLITERANS FOR SYMPATHETIC GANGLIONECTOMY

Sympathetic ganglionectomy has had its widest application to thromboangiitis obliterans among diseases of the occlusive type. This disease is a chronic, inflammatory, obliterating arteritis, affecting chiefly the larger arteries of the arms and legs, and is characterized by a relapsing course. The thrombosis is inflammatory and is deposited in a segmental manner. The clinical aspect of the disease varies with the rapidity of the thrombosing process and the ability of the collateral circulation to keep pace. This point is important in attempting to interpret the effects of

treatment and in selecting cases for operation. In the majority of cases of thrombo-angiitis obliterans varying grades of vasoconstriction can be demonstrated. There is a close correlation between the severity and stage of the disease and the amount of vasoconstriction. In cases with a short history of claudication and marked diminution of the arterial blood supply to the digits there is marked rubor, diminished surface temperature and trophic changes in the skin, and the vasomotor component is usually low. Conversely, in cases with longer histories, two years or more, the signs of arterial insufficiency are not pronounced, the course of the disease is relatively slow, and the vasomotor component is relatively high.

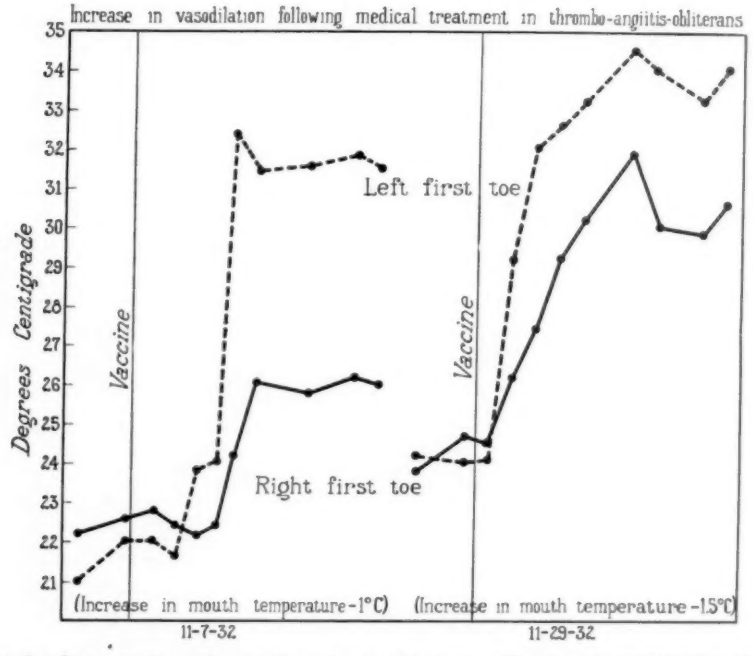

Fig. 1.—Increase in surface temperature with fever. The first determination shows incomplete vasodilatation in the first right toe. After a period of active medical treatment the vasodilatation in this digit showed a sharp increase sufficiently high to justify operation.

Selection of cases for sympathetic ganglionectomy rests upon two major points: (1) the demonstration of high degrees of vasoconstriction, and (2) the clinical aspects of the case. A mathematical expression as a basis for instituting operative measures constitutes only one determinate, and it should not exclude the obvious clinical features that are of equal importance. These are: (1) The general condition of the patient. Many patients who have suffered greatly from pain, loss of sleep, or from excessive use of tobacco or opiates, should not be subjected to a major operation without a preoperative period of treatment.

Coronary disease is not an uncommon complication of thrombo-angiitis obliterans, and sudden death in this disease does occur. (2) The occupational hazards with respect to the extremities, if the livelihood of the patient depends on the use of the feet or hands, or if his occupation involves exposure to the rigors of the weather in northern climates, the need of the operation for protection is clear. (3) The stage of the disease. We are of the opinion that certain failures of this operation to obtain the expected results have been due largely to the fact that it has been carried out during a stage of acute advanced arterial insufficiency in the presence of ulcers and severe rest pain. We have amply demonstrated that sympathetic ganglionectomy is not effective in this phase of the disease. Before operation is undertaken, it is extremely important to control the pain by adequate medical treatment and to demonstrate the potentiality of the ulcer for healing. A period of active treatment and a lapse of time will frequently demonstrate a sharp increase in the vasomotor component (Fig. 1). A low vasomotor component is usually found in digits with ulcers or trophic lesions, or during the period of acute arterial insufficiency following recent thrombosis. If fever therapy and other medical measures do not relieve the pain, initiate healing, and demarcate the gangrenous tissues, it has been our experience that operative measures are likely to fail.

THROMBO-ANGIITIS OBLITERANS WITH LUMBAR GANGLIONECTOMY

To determine the validity of prediction based on preoperative studies of the vasomotor components, the vasomotor indices, the vasomotor range, and maximal vasodilatation level have been compared with the postoperative surface temperatures in the same digits, taken at varying intervals after operation. Complete data are here presented from fifty-five cases of thrombo-angiitis obliterans in which lumbar sympathetic ganglionectomy was performed and in which temperature studies were complete (Table I). The average vasomotor index for the group was 4.4. In this group were eleven cases in which vasomotor indices were below 2. Operation was carried out because of the relatively high values obtained for the other vasomotor factors and the favorable clinical aspects of the cases. The number of cases with low indices was insufficient to make a correlation with the postoperative increases in the surface temperature. In the group with vasomotor indices less than 2, the maximal vasodilatation level attained by operation was approximately 2° less than in the group with vasomotor indices more than 2. In the majority of cases the operation was carried out only when vasomotor indices were relatively high.

Vasomotor range.—Increase in temperature with fever was 5.6° C. compared with increase from operation of 5.4° C., a remarkably close

TABLE I

COMPARATIVE EFFECTS OF FEVER AND SYMPATHETIC GANGLIONECTOMY: AVERAGE VALUES

	MAXIMAL TEMPERATURE, DEGREES C.		INCREASE* IN TEMPERATURE		VASOMOTOR INDEX
	WITH FEVER	AFTER OPERATION	WITH FEVER	AFTER OPERATION	
Thrombo-angiitis obliterans					
Toes	31.5	31.3	5.6	5.4	4.4
Fingers	32.7	30.8	6.7	4.8	4.7
Raynaud's disease					
Toes	32.3	33.7	8.0	9.4	6.9
Fingers	34.4	31.1	9.2	5.9	7.8
Scleroderma					
Toes	33.7	30.9	9.3	6.5	7.8
Fingers	34.6	31.3	8.6	5.3	6.5
Arthritis					
Toes	33.2	32.7	7.1	6.6	4.6
Fingers	35.7	33.4	8.7	6.4	4.5

*Mouth temperature deducted from these values.

approximation. The average maximal vasodilatation level obtained with fever was 31.5° C. as compared with 31.3° C. obtained with operation.

THROMBO-ANGIITIS OBLITERANS WITH CERVICODORSAL GANGLIONECTOMY

There were twelve patients in this group, all of whom had trophic lesions involving the fingers. The bilateral operation was done in all cases. The average vasomotor index for the group was 4.7, and in no case was it lower than 2.2. There was no close correlation between the vasomotor index and the postoperative surface temperatures. The vasomotor range of the fingers with fever showed a mean increase of 6.7° C. as compared to 4.8° C. increase with operation. The maximal level of vasodilatation for the group with fever was 32.7° C. as compared to 30.8° C. obtained with operation.

In the upper and lower extremities there are significant differences in the response of the surface temperature with fever and with sympathetic ganglionectomy. In the feet the approximations in the surface temperature are extremely close with fever and with operation, for the vasomotor range and maximal vasodilatation. In 90 per cent of the cases the variation was less than 1.5°. When greater variation was obtained, a technical error may have been accountable, or thrombosis may have occurred in the interval. In the hands the vasodilatation from fever exceeded by significant differences that obtained by operation. This may be explained in part by the fact that in some of our early cases in which operation had been performed there occurred incomplete removal of the vasomotor fibers, as determined by sweating tests. A further explanation is that after sympathetic denervation there is some

fundamental difference in the behavior of the autotonus of the arteries of the hands as compared to that in the feet. It was observed that in cases in which complete sympathectomy had been performed the variation in the surface temperature of the fingers to environmental changes was greater than that in the toes after lumbar sympathectomy.

RAYNAUD'S DISEASE WITH LUMBAR SYMPATHETIC GANGLIONECTOMY

There were nine cases in this group. The average values for vasomotor indices, vasomotor range, and maximal vasodilatation levels are shown (Table I). The vasomotor indices were high in all but one instance; the

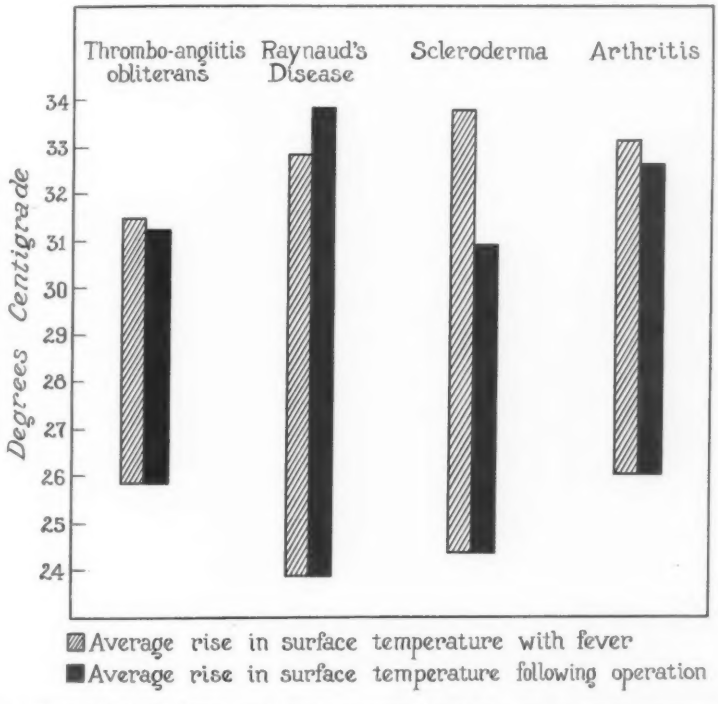

Fig. 2.—The effect of fever and lumbar sympathectomy on surface temperature.

average was 6.9. The vasomotor range with fever was 8° C. as compared to 9.4° C. with operation. The maximal level obtained with fever for the group was 32.3° C., as compared to 33.7° C. with operation. In two cases much higher values were obtained after operation than were obtained with fever (Fig. 2).

RAYNAUD'S DISEASE WITH CERVICODORSAL SYMPATHETIC GANGLIONECTOMY

There were thirteen cases in this group. Vasomotor indices were high in all cases, averaging 7.8; in none were values lower than 4 noted. The vasomotor range was 9.2° C. with fever and 5.9° C. increase in surface

temperature with operation. The maximal vasodilatation level was high with fever averaging 34.4° C., as compared to 31.1° C. with operation (Fig. 3).

In Raynaud's disease the correlation of the preoperative and postoperative surface temperatures with fever is not so close as in thrombo-angiitis obliterans. If the diagnosis is correct and trophic lesions are slight, high grades of vasodilatation will be obtained with fever and with complete sympathectomy. The usefulness of preoperative studies of the vasomotor component is distinctly less than in thrombo-angiitis obliterans. It is interesting to observe that as in thrombo-angiitis oblit-

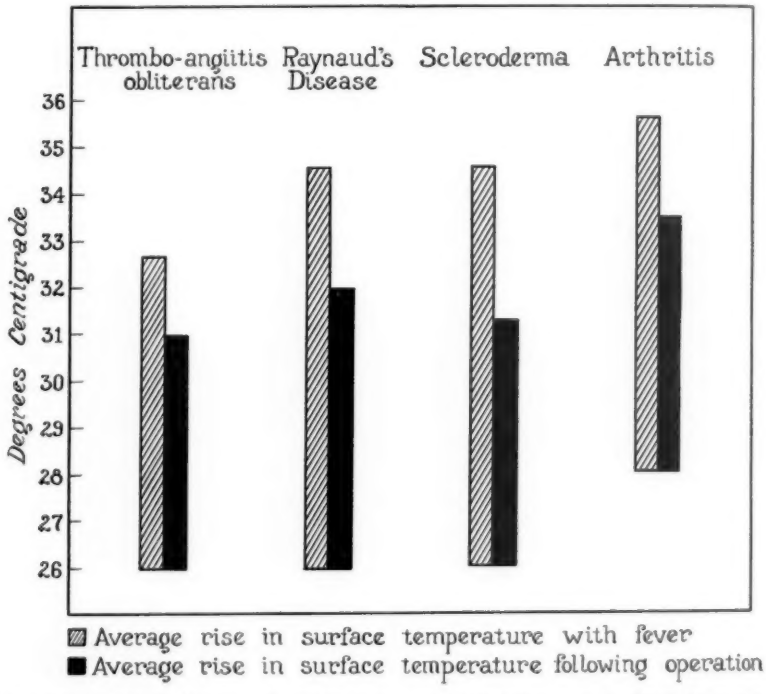

Fig. 3.—The effect of fever and cervicodorsal sympathectomy on surface temperature.

erans, higher grades of vasodilatation occurred in the hands with fever than in the toes. Vasodilatation from operation in the hands was significantly less than that with fever, whereas in the feet higher grades of vasodilatation followed operation than were obtained with fever.

SCLERODERMA

There were twenty-four cases in this group (Table I). Cervicodorsal ganglionectomy was performed in fifteen and lumbar ganglionectomy in eight. Vasomotor indices were high in the entire group. The average value for the fingers was 6.5, and for the feet, 7.8. No close correlation between these indices and the postoperative surface temperatures was

found. The vasomotor range had a greater increase with fever than with operation, and a similar discrepancy was demonstrated in the comparison of the maximal vasodilatation levels. The average high point in the same digits was 34.6° C. with fever and 31.3° C. with operation. In the group of nine cases in which lumbar ganglionectomy was performed the average vasomotor range with fever was 9.3° C. and with operation 6.5° C. The maximal vasodilating level with fever was 33.7° C. and with operation 30.9° C.

The greatest discrepancy between the vasodilatation with fever and that with operation was shown in cases of scleroderma with vasomotor phenomena. This held true for both feet and hands. Incomplete operation would not explain this difference in the feet, as incomplete sympathectomy has not occurred in lumbar ganglionectomy. There are pathological changes in the skin and subdermal structures in scleroderma which do not exist in other vascular diseases.[2] There is a quantitative diminution in the capillaries, and obliterative lesions are demonstrable in the digital arteries. The increased density of the cutaneous tissues may increase radiation of heat during fever producing abnormally high surface temperatures, and they are not solely a result of dilatation of cutaneous arterioles. The problem of selection of cases of scleroderma for sympathetic ganglionectomy is difficult, and the results of operation have not been comparable to those obtained in the other forms of circulatory diseases without dermal involvement. Slightly higher grades of vasodilatation from operation were noted in the hands than in the feet.

ARTHRITIS

In this group there were five cases in which cervicodorsal ganglionectomy was done. The vasomotor indices and vasomotor range were high in the hands, averaging 4.5° and 8.7° C., respectively; the postoperative surface temperatures were high in all cases. The maximal surface temperatures were 35.7° C. with fever and 33.4° C. with operation.

In all of the thirteen cases in which lumbar sympathectomy was performed the vasomotor indices, ranges, and maximal surface temperatures were high with fever, and postoperative surface temperatures averaged 32.7° C. For the group there was 0.5° C. greater increase with fever than with operation (Table I).

In arthritis, sympathectomy was carried out in the presence of abnormal degrees of vasoconstriction and localization of the arthritis in the peripheral parts. No organic lesion of the arteries was present, and the maximal grades of vasodilatation were obtained with fever and with operation. In the group a higher grade of dilatation from operation was obtained in the hands than in the feet, which is contrary to the

effect observed in thrombo-angiitis obliterans and in Raynaud's disease. Removal of the lumbar and cervicodorsal ganglia in patients with arthritis demonstrated conclusively the effectiveness and permanency of vasodilatation. Many of these cases have been followed and surface temperatures tested repeatedly over a period of years. In none have the surface temperatures shown values less than 30.7° C. in the hands and 31.8° C. in the feet. Preoperative studies of the vasomotor components did not give important prognostic information in the cases of arthritis.

COMMENT

Prediction of the degree of vasodilatation that may be expected from sympathetic ganglionectomy is possible within certain limits. The limitations are related to the character of the disease, the completeness of operation, and the presence or absence of abnormal changes in the skin, such as infections, ulcers, and fibrosis. In purely vasospastic disturbances vasodilatation will take place if the operation is complete, and preoperative procedures are not necessary for prognosis. Arthritis and early cases of Raynaud's disease fall in this group. In the presence of occlusive disease of the arteries determination of the available vasodilatation is important. Vasomotor control of the collateral vessels has been well shown in the experimental animal. Mulvihill and Harvey have demonstrated a rapid restoration of the peripheral circulation when sympathetic ganglionectomy was done after the iliac arteries were ligated. In man, after sympathetic ganglionectomy, the increase in circulation is variable in the presence of occlusive disease of the peripheral arteries. Several factors are responsible for this: first, the collateral circulation may be involved in the occlusive disease; second, collateral circulation may be incompletely developed because of the rapid progress of the obliterating process, and third, the presence of ulcers or gangrene impairs vasodilatation in the area thus affected. The demonstration of high grades of vasodilatation before operation does not give accurate prognostic information as to the subsequent course of the occlusive disease, and this fact needs emphasis in respect to thrombo-angiitis obliterans. For prognosis the clinical course is as important as the available vasodilatation in a given stage of the disease. This operation is a therapeutic procedure of high efficacy in that the maximal available vasodilatation will be obtained, but it will be modified by the subsequent course of the obliterating disease. The problem in a given case is whether this maximal vasodilatation will relieve pain, effect healing of an ulcer, or modify relapsing thromboses. In the absence of ulcers or pain the operation is advocated for its protective function by preventing or minimizing subsequent trophic lesions. This protective function has been

amply demonstrated. In cases of ulcers, edema, and rest pain, evidence of healing and pain relief should be demonstrated by medical measures before operation is advised.

The demonstration of an abnormal degree of vasoconstriction in the extremities by fever or anesthesia is one of the requisites for advising operation in thrombo-angiitis obliterans. Fever produces effective dilatation in 98 per cent of the cases. Two of our patients failed to obtain dilatation with anesthesia but showed vasodilatation with fever. The problem in the selection is, what values or limits of vasodilatation should be established to make operation advisable? In our early work with the vasomotor index it was felt that the surface circulation should show an increase at least twice the rise of temperature in the mouth or blood. This divided the cases into two groups, those with excessive and those with minimal degrees of vasoconstriction. From the clinical standpoint this was satisfactory, and the results demonstrated the usefulness of this criterion. Later the rise in surface temperature (vasomotor range) was studied, and an increase of at least 4° C. was established as an index for operation. Certain errors could develop in both of these methods, in that a basal surface temperature could not always be obtained, and during hot weather the surface temperature could be high, thus giving abnormally low values. The maximal surface temperature of the digit most affected was then taken as a basis for prediction. This could not be affected by shifts in the surface and environmental temperatures. Preoperative and postoperative studies showed that this value gave the highest correlation and was less subject to error. A maximal surface temperature of 29° C. or higher with fever was regarded as necessary for justifying operation.

It must be kept in mind that thrombo-angiitis obliterans is a relapsing disease. There is no conclusive proof that ganglionectomy prevents recurrence of thrombosis. We believe it decreases the incidence of recurrence, but we have seen several patients in whom recurrences of arterial thrombosis have taken place months after operation. The protective nature of the operation against loss of limbs was demonstrated in these cases.

The selection of cases for sympathetic ganglionectomy in other types of vascular disease by quantification of the vasomotor component is not crucial. In cases of Raynaud's disease a high degree of vasoconstriction is the rule. Superficial ulcers, secondary infections, and thrombosis of the digits may produce variations in different digits.

In vasomotor forms of scleroderma affecting the extremities vasomotor studies are of some value. However, it has been our experience that the postoperative temperatures do not attain the levels of surface temperatures resulting from fever. Injections of opaque substances into the arteries in cases of scleroderma have shown that in this disease

there are occlusive lesions of the smaller arteries or arterioles.[3] Further, there is a quantitative diminution of the capillaries in the skin, and also secondary changes in the subcutaneous tissues which are irreversible and which cannot be restored by operation. There is, however, a certain protective value against the progression of the disease and the subsequent development of ulcers and progressive fibrosis.

In arteriosclerosis obliterans we do not believe that sympathetic ganglionectomy is advisable. There may be an occasional case in which patients are in the fifth or sixth decade of life where it can be used with beneficial results. Most of these patients, however, have other foci of arteriosclerosis, and in these the risk is abnormally high. It is unwise to employ the use of fever in arteriosclerotic subjects, because thrombosis tends to develop in these patients.

SUMMARY

Sixty-seven cases of thrombo-angiitis obliterans have been studied to determine the prognostic value and relation of the peripheral vasodilatation attained with systemic fever to the increase of surface temperature following sympathetic ganglionectomy. A close approximation is shown. This correlation is higher in the feet than in the hands. Other factors in the selection of cases of this form of vascular disease for operation are important, particularly those of the integrity of the coronary arteries, the rate of progression and stage of the disease, and the ability to demonstrate healing and relief of pain by medical measures. About one-third of the cases are suitable for operation. Preoperative determinations of the vasomotor component are less essential in the pure vasomotor disorders and in arthritis. Maximal grades of vasodilatation will result if the operation is complete.

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THE POSITION OF THE HEART VALVES AND THEIR RELATION TO THE ANTERIOR CHEST WALL IN LIVING SUBJECTS WITH ABNORMAL HEARTS*

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THE position of the heart valves in relation to the chest wall is of great significance in physical diagnosis. However, surprisingly little is known about it, particularly when the heart is enlarged. The method of dissection in the hands of anatomists has concerned itself chiefly with hearts of normal size, and even here there is considerable difference in the descriptions given by different anatomists. Methods used by them to localize the valves could hardly be termed satisfactory, and distortion from the position in life easily was possible. Roentgen ray methods seem to have been applied in only three studies, those of Groedel (1912),[1] of Norris and Fetterolf (1912 and 1913)[2, 3] and of LeWald (1916).[4] Groedel studied hearts removed from the chest and so threw no light on the relation of the valves to the chest wall. Norris and Fetterolf cut the thorax of 15 cadavers, preserved by formalin and frozen, into frontal sections one inch thick parallel with the anterior chest wall, separated the sections and covered the surfaces of the heart valves with lead paint; after superimposing these sections in order, roentgenograms were taken, and the shadows of the valves, covered with lead paint, appeared in their true position in the roentgenograms. LeWald followed the general plan of Norris and Fetterolf but localized the valves by inserting metal rings from the auricular side into the position where the valves joined the heart wall. Roentgenograms were taken in the postero-anterior, lateral and superior planes; these revealed unequivocally the position of the valves in the one cadaver studied. All of these studies showed the valves as located close together; the methods used did not exclude changes in position that might easily have occurred following death, and were of no help in localizing the valves in abnormal hearts. Physical examination of patients with abnormal hearts and especially those that were greatly enlarged has thrown doubt on the fixed relationships of heart valves to chest wall, as indicated by these anatomical studies.

Our observations on the visualizing in the living patient of calcium deposits in the aortic and mitral valves and in the annulus fibrosis of the mitral valve have given us a method of localizing the position of the

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heart valves in relation to the chest wall. These show that the actual position of the valves in the living subject varies greatly from patient to patient.

Technic.—The roentgenological and fluoroscopic technic has been discussed in detail in our previous report.[5] To locate these calcified valves fluoroscopically, adequate preparation of the eyes is essential. A four-and-one-half- to five-inch gap (70-75 K.V. self-rectified) with five milliamperes of current usually is sufficient. A very small aperture should be used to eliminate secondary radiation. Observing these precautions the auriculoventricular junction on the left border of the heart con-

Fig. 1.—Seven superimposed orthodiagrams of aortic stenosis with calcification. The calcified deposit, left and right cardiac borders, and chest walls have been similarly numbered in each case.

tour may be located by its V-shaped depression and lack of pulsation. A search through the heart shadow below and medial to this point will disclose the dancing shadows cast by the calcium deposits if they are present in the mitral area. Calcifications in the aortic area usually are hidden by the vertebral column in the postero-anterior projection making oblique positions indispensable. A slight right antero-oblique position is best for visualization of the calcified aortic valves. Deep inspiration with an arrest of the respiratory cycle often helps in differentiating shadows in the lungs and mediastinum from those in the heart.

For radiograms it was found satisfactory to use an exposure of one-thirtieth of a second with a maximum milliamperage of 200, distance of thirty inches, using

fast screens and speed films, and a two-and-one-half-inch cylinder, directed accurately at the valve, to cut down secondary radiation.

The orthodiagrams were prepared in the usual manner. A skin pencil with a lead sheath (making it visible through the fluoroscope) was used to trace out the cardiac outline and valve positions on the patient's chest using at all times a small aperture and parallel rays. The ribs were sketched in afterward and photographs taken in the standing position. For diagrammatic and demonstration purposes these outlines were also traced on clear roentgen films.

As a result of these studies we present two diagrams showing the position of the calcified portions of the aortic and mitral valves. Fig. 1

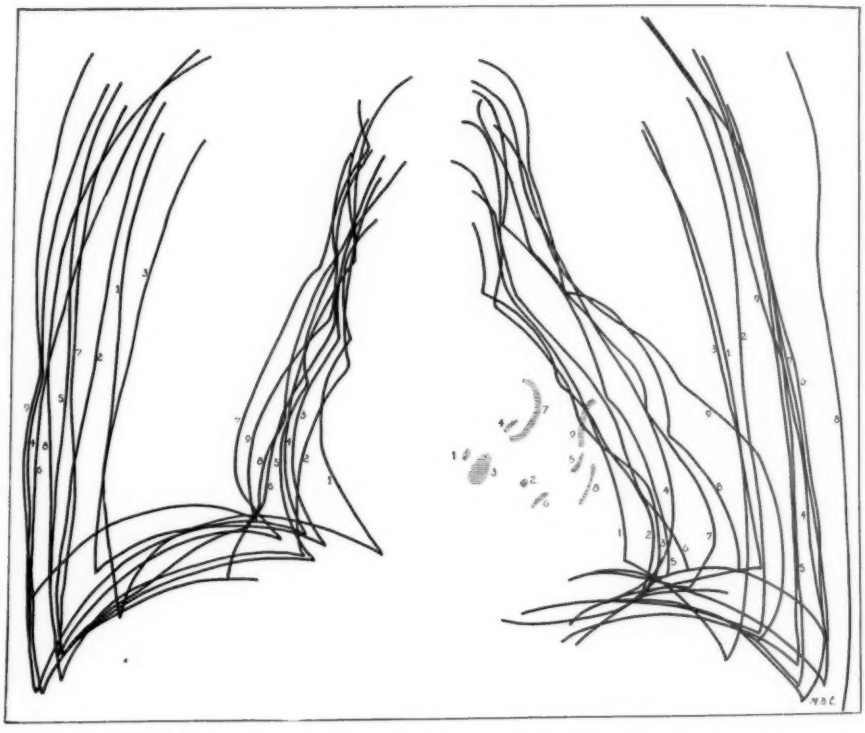

Fig. 2.—Nine superimposed orthodiagrams of mitral stenosis with calcification. The calcified deposit, left and right cardiac borders, and chest walls have been similarly numbered in each case.

shows superimposed orthodiograms of seven cases of aortic stenosis with calcification; it shows the outline of the heart borders and the chest wall numbered the same as is the corresponding calcified area for that particular heart. The variation in the location of the valves is easily seen.

Fig. 2 represents nine superimposed orthodiagrams of mitral valve calcifications similarly numbered. Fig. 3 represents orthodiagrams of six cases of calcifications in the annulus fibrosis also similarly numbered. These show the larger semicircular calcified areas which partially sur-

round the mitral valve and anatomically form the attachment for the valve cusps. Also in these hearts of older patients the degree of enlargement is seen to be less.

Fig. 4 shows two cases of aortic valve calcification. The variability of the valve position in relation to the xiphoid process is clearly brought out. In Case B the mark for the valve calcification is seen to be immediately over the xiphoid process. This patient was proved to have aortic valve calcification by post-mortem examination. There is no way to reconcile this low position of the valve with the textbook position

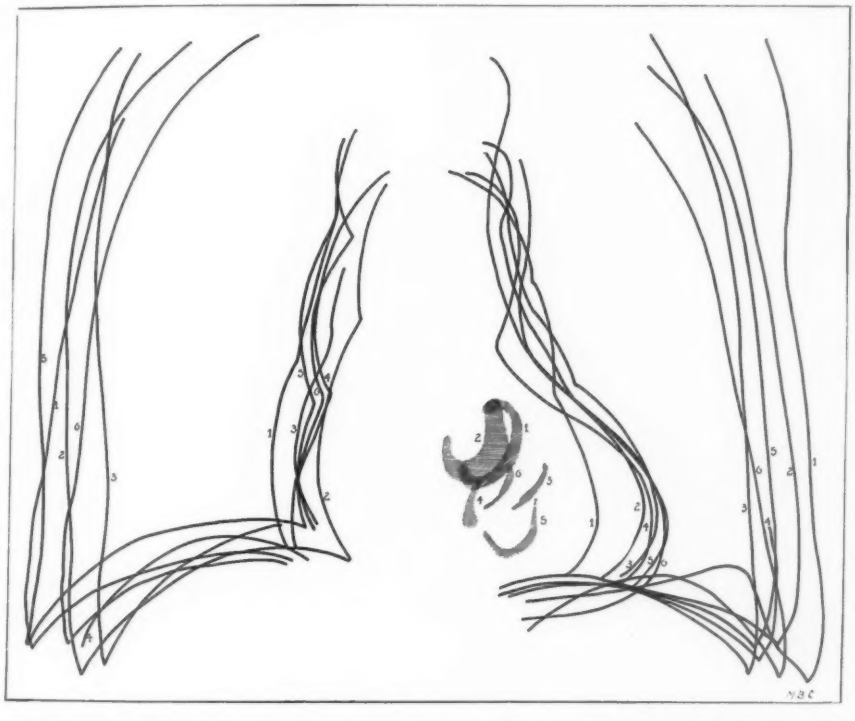

Fig. 3.—Six superimposed orthodiagrams of mitral annulus fibrosis calcification. The calcified deposit, left and right borders, and chest walls have been similarly numbered in each case.

unless we consider the explanation to be an elongation of the aorta with consequent depression of the right border downward and a rotation of the apex outward.

Fig. 5 shows two cases of calcified mitral valves. Noting the great difference between the heart contours of these two patients one would not expect the valve positions to be similar. The left auricular hypertrophy in Case D is posterior. The calcification in the mitral valve has been confirmed by pathological examination.

From these observations the following deductions may be drawn with regard to the position of the aortic and mitral valves in patients with abnormal hearts:

1. Both valves are likely to be found on a line 45 degrees from the horizontal, starting at the auriculoventricular groove on the left border

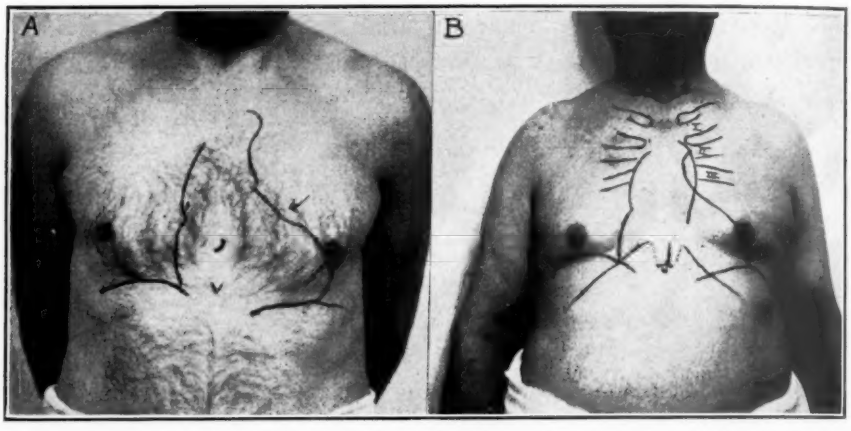

Fig. 4.—Two cases of aortic stenosis with calcification. The curved line near the midline represents the position of the calcified valve in Case A. The xiphoid process is shown by "v." The arrow on the left border marks the auriculoventricular junction. In Case B the calcified valve is seen to be directly over the xiphoid process.

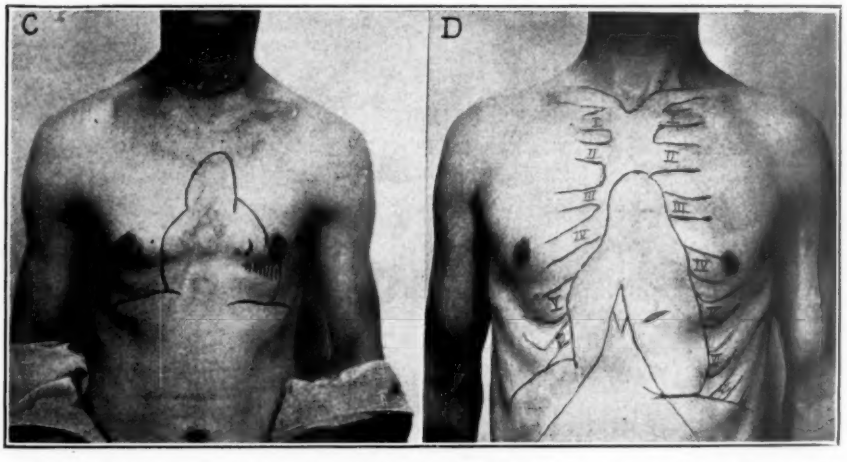

Fig. 5.—Two cases of mitral stenosis with calcification. The vertical lines below the calcified area in Case C represent the area where the thrill was of greatest intensity. Case D shows the calcified area to the left of the xiphoid process. The auricular bulge in Case D was most marked posteriorly.

of the heart shadow, this line corresponding to the position of the auriculoventricular groove. Fluoroscopically the calcified aortic valve if not on this line is likely to be medial to or above it, while the mitral valve varies lateral to and below it.

2. The mitral valve is likely to be more to the left of the midline than the aortic valve, and the latter may be exactly in the midline.

3. The aortic valve usually is more caudad than the mitral valve in relation to the chest wall, but may be more cephalad in relation to the total bulk of the heart shadow. This is probably due to the predominance of the left ventricle in aortic disease and to the large dilated auricles in mitral disease.

4. In the right anterior-oblique position the two valves may occupy the same position in relation to the cardiac outline, so that this view, although the one in which it is easiest to see the valves, is of no value in determining which valve is calcified.

5. The left anterior-oblique view is the best for differentiating between aortic and mitral valve calcifications, but is the most difficult, because in this position the roentgen rays must traverse the maximum thickness of the heart. Small areas of calcifications visible in the other oblique view may not be visible in this view. If large enough to be seen in the left anterior-oblique position, the mitral valve calcifications will be found to lie in the posterior one-third of the heart shadow, while the aortic valve calcifications are usually in the middle one-third. If the posterior cusp of the mitral valve is calcified, it may be within one centimeter from the posterior surface of the heart shadow. The chief difficulty lies in deciding between calcification of the anterior mitral leaflet and that of the posterior aortic cusp. (It is important in this position to have the posterior surface of the apical portion of the heart just clear of the shadow of the spine.)

6. In calcified annulus fibrosis cases the shadows are likely to be larger and denser, usually J-, ↄ- or U-shaped, and on the films are more homogeneous in appearance than the irregularly mottled calcifications in the mitral leaflets. They occur frequently in patients without discoverable heart disease (although several cases of calcified mitral annulus fibrosis had slight aortic stenosis, uncalcified) and are usually found in patients sixty years of age or older.

7. If both valves are calcified, they may move independently; i.e., their dancing excursions with the heartbeat are not synchronous, but are consecutive. Further details on this part of the problem await the development of an accurate timing mechanism.

CONCLUSION

Great variations in position of the aortic and mitral valves occur as the heart enlarges or otherwise changes its relations to the thoracic cavity. This has an important bearing on the localization and distribution of murmurs and is of great significance in the interpretation of physical signs.

The authors wish to express their sincere appreciation to Dr. Henry A. Christian for his many helpful suggestions and valuable criticisms.

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THE INTERPRETATION OF THE GALVANOMETRIC CURVES OBTAINED WHEN ONE ELECTRODE IS DISTANT FROM THE HEART AND THE OTHER NEAR OR IN CONTACT WITH THE VENTRICULAR SURFACE*

Part I. Observations on the Cold-Blooded Heart

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INTRODUCTION

IN A RECENT study of the electrocardiographic changes that follow the ligation of a large coronary artery we made extensive use of leads in which one electrode was placed very near the heart or in contact with its exposed surface and the other as far from the heart as possible. In the course of this study the correct interpretation of the curves so obtained became a matter of importance, and certain questions that arose in this connection led us to investigate the following subjects: (1) The changes that curves obtained by leading directly from the exposed heart, in the manner described, undergo when the heart is completely immersed in a conducting medium and the direct contact is moved away from its surface. (2) The nature of the electrical responses of injured heart muscle and the factors that influence their form in direct and semidirect leads. (3) The potential variations that occur in the ventricular cavities and the relations between them and the potential variations recorded at the epicardial surface. Part I of this paper deals with experiments performed on turtles. In these experiments only the first two of these subjects were studied. Part II (published separately) deals with a series of observations on the mammalian heart, concerned, for the most part, with the third subject listed.

In studying the first of these problems we had in mind the objections raised by Bishop and Gilson[1] to the interpretation placed by Craib[2] on certain curves which he obtained by leading directly from the air-exposed surface of tissues partly immersed in a conducting medium. A few words of explanation are perhaps desirable. It can scarcely be doubted that the electric currents produced by an excitable tissue completely immersed in an extensive conducting medium are distributed in accordance with the laws that define the flow of electric currents in volume

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conductors. From the character of these laws it follows that a curve obtained by pairing an electrode very close to the tissue with an electrode very far from it may be regarded as representing the potential variations of the former (Wilson, Macleod and Barker[3]). By comparison the potential of the distant electrode must be very nearly constant. Craib[2] employed such leads in studying the action currents of immersed and partly immersed tissues and interpreted his records in accordance with this principle. He made no distinction, and apparently saw no difference, between those experiments in which the tissue and the near electrode were fully immersed in the conducting medium and those in which the tissue surface with which this electrode was in contact was exposed to the air. He evidently regarded the tissue itself and the film of fluid adhering to its air-exposed surface as merely a part of the surrounding conductor. With this opinion we are in complete agreement. Bishop and Gilson adopted a different point of view, and criticized Craib's conclusions on several grounds. In their paper they ignored the laws that define current flow in volume conductors, and treated experiments of the kind mentioned as if the various conductors involved were parts of a network. They attributed many of Craib's findings to asymmetry of the tissue environment. According to their view it is not legitimate to assume that the potential variations of the distant electrode are negligible when this electrode is paired with an electrode in contact with the air-exposed surface of a partly immersed tissue. They spoke of the direct contact, when so placed, as partially insulated from the surrounding medium, and implied that its potential variations are entirely different from those that would occur in the medium near the point with which it is in contact if the tissue were completely submerged.

If these conclusions are correct and apply to leads from the exposed heart, it is not permissible to interpret the ventricular complexes obtained by precordial and by semidirect leads in accordance with the principles that apply to the interpretation of curves obtained by leading directly from the ventricular surface. Although our previous experience led us to believe that semidirect leads from a given region on the surface of the immersed heart and direct leads from the same region when it is exposed to the air yield curves of strikingly similar outline, it seemed desirable to obtain further information on this point.

In studying the responses of injured heart muscle we had several objects in view. We sought, first of all, to arrive at a more complete understanding of the factors that determine the direction and magnitude of the displacement of the RS-T segment of the ventricular complex which occurs immediately after the ligation of a coronary artery. As has frequently been observed, the same phenomenon is seen whenever the heart muscle is injured locally. In the second place we desired to con-

firm and extend the observations made by Wilson, Macleod and Barker[3] and to test the utility of the hypothesis advanced by them to explain the monophasic responses obtained from injured tissues partly or completely immersed in a conducting medium.

METHODS

Our first experiments were carried out on turtles (Graptemys geographica). The animal was pithed, and the heart was exposed by removing the plastron or by cutting out that portion overlying the heart with a trephine. Two string galvanometers arranged in tandem enabled us to obtain two simultaneous records on the same film. One of these galvanometers was used in the ordinary way; the other was connected to the balanced plate circuit of a vacuum tube operating at its free grid potential (Wilson, Johnston, Macleod and Barker[4]). One terminal of each apparatus was attached to an Ag- AgCl electrode placed as far as possible from the heart. In some instances these indifferent electrodes were placed on the tail or one of the hind legs. In other instances the turtle was placed on its back in a large shallow dish filled with Ringer's solution with which the indifferent electrodes were in contact at a point as far from the animal as possible. The other terminal of each apparatus was attached to an exploring electrode which could be placed on or near the heart as desired. The exploring electrodes consisted of small glass tubes stoppered with salted kaolin and filled with Ringer's solution into which a coil of silver wire coated with silver chloride was thrust. The contact with the heart was made by a wick imbedded in the kaolin plug and allowed to project several millimeters beyond the glass tube. In some instances this wick was left bare; in others it was inclosed in a small rubber tube so that it was insulated to within one or two millimeters of its end. When such electrodes are placed in a conducting medium, the effective electrode surface is, of course, at the end of the insulated shaft.

DESCRIPTION OF EXPERIMENTS

In describing illustrative experiments it will be convenient to differentiate between the two exploring electrodes by calling one of them the x-electrode and the other the y-electrode. We shall use the former term to designate the electrode connected to the galvanometer responsible for the upper curve in our records, and the latter to designate the electrode connected to the grid terminal of the vacuum tube amplifier and thus indirectly to the galvanometer responsible for the lower curve. The connections were always so made that relative negativity of the exploring electrode produced an upward deflection. The time intervals shown on the records are fifths of a second.

Experiment I. The heart was exposed by trephining the plastron, and the animal was placed in a shallow dish containing Ringer's solution. The indifferent electrodes were in contact with this solution at a point 16 cm. from the nearest part of the turtle. The wick of the x-electrode was bare and extended 3 mm. beyond the glass shaft. The wick of the y-electrode was inclosed in a small rubber tube which extended to its tip. Both exploring electrodes were placed in contact with the ventricle approximately at the center of its ventral surface. They were very close together. After taking control curves (Fig. 1 *A*) the heart was flooded with saline (0.9 per cent NaCl) to a depth of approximately 8 mm. This resulted in a conspicuous reduction in the size of both curves (Fig. 1 *B*), but the upper curve fell off more in proportion to its original size than the lower. When the added fluid was removed by aspiration and the surface of the heart dried by blotting, the deflections of both curves regained their original magnitude (Fig. 1 *C*). With one exception neither the direction nor the relative size of these deflections was

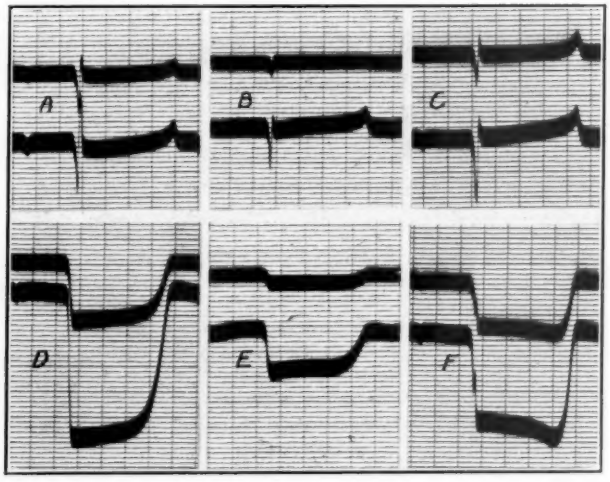

Fig. 1.—Experiment I. Exploring electrodes close together on ventral surface of turtle's ventricle. Indifferent electrodes 16 cm. from turtle (see text). Ordinate scale; lower curve, 5 mv. per centimeter; upper curve uncertain (see text). In all experiments the connections were so made that negativity of the exploring electrode produced an upward deflection in the corresponding curve. *A*, control; *B*, after immersing heart in 0.9 per cent NaCl; *C*, after removing saline and drying heart's surface; *D*, after burning tissue beneath exploring electrodes; *E*, after again immersing heart in saline; *F*, saline removed and heart dried.

altered either by flooding or by drying the heart. The upward deflection at the end of the QRS interval originally present in the lower curve was very much smaller in subsequent records. Since it did not regain its former size when the heart was dried, this change was probably due to a slight shift in the position of the y-electrode when fluid was poured over the heart.

The next step was to burn a small area immediately beneath the exploring electrodes with a hot iron. The ventricular complexes of both curves were immediately transformed into downwardly directed, monophasic deflections (Fig. 1 *D*). When the heart was flooded, the size of these deflections was greatly reduced, but their general outline was not changed (Fig. 1 *E*). The upper curve again fell off proportionately more than the lower. When the added fluid was removed, both curves increased in size, but neither quite regained its original amplitude or its original form

(Fig. 1 *F*). The appearance of a notch in each curve at the point where the chief upstroke or intrinsic deflection began before the heart was injured by burning should be noted.

In one respect this experiment was imperfect. When the first curves were taken, the tension of each galvanometer string was adjusted to give a deflection of 1 cm. for a potential difference of five millivolts. When the experiment was completed, however, it was found that the sensitivity of the galvanometer responsible for the upper curve was less than one-half the desired value. It is not known whether an error was made in adjusting the string tension or whether the sensitivity of this instrument fell off during the course of the experiment. The lesser size of the upper curve in the records taken when the heart was not immersed is, therefore, probably due to faulty standardization.

When fluid was poured upon the heart, the effective surface of the x-electrode, which was furnished with a bare wick, necessarily receded 2 or 3 mm. from the heart, and converted the previous direct lead into a semidirect lead. The effective surface of the y-electrode, which was rubber-tipped, also moved away from the heart, but the movement must necessarily have been very small. This difference between the two electrodes accounts for the proportionately greater reduction in the size of the upper curve when the heart was flooded. A similar difference between wick and rubber-tipped electrodes was observed in all experiments in which they were compared. Even when the heart has been blotted dry, some fluid clings to its surface and, in experiments of the kind under consideration, more soon collects. Rubber-tipped electrodes, which can be brought into more intimate contact with the muscle, are therefore likely to yield somewhat larger curves than wick electrodes unless care is taken to keep the surface of the heart as dry as possible.

Experiment II. In this instance the indifferent electrodes were placed on the tail. Both exploring electrodes were rubber-tipped, but the wicks extended approximately 1.5 mm. beyond the insulation. These electrodes were placed on the ventral surface of the exposed ventricle; the x-electrode near the base on the left side, and the y-electrode on the right side near the apex. The distance between them was about 13 mm. After some preliminary observations the surface of the heart was dried, and a set of control curves was taken (Fig. 2 *A*). When the heart was flooded to a depth of 5 mm., both curves became very much smaller (Fig. 2 *B*). The size of all the deflections was then doubled (Fig. 2 *C*) by reducing the tension of both galvanometer strings until a potential difference of ten millivolts produced a deflection of 4 cm. instead of 2 cm. As the fluid drained away, there was a further increase in their magnitude (Fig. 2 *D*), and when the heart was dried they became still larger (Fig. 2 *E*). Apart from these changes in amplitude both curves maintained their original outline; the direction and relative size of the various deflections remained the same throughout.

After repeating these observations another control curve (Fig. 2 *F*) was taken, and a small area (about 5 mm. in diameter) beneath the x-electrode was then burned. The ventricular complexes of the upper curve promptly became monophasic (Fig. 2 *G*), but it should be noted that the injury altered only those portions of the ventricular complex that occurred after the onset of the chief upstroke or intrinsic deflection. The shape of the downstroke that preceded this deflection was not changed; the monophasic curve is marked by a notch at the point where this downstroke ends. The change produced by the injury in the form of the lower curve was less pronounced but nevertheless definite. It consisted in a very distinct elevation of the RS-T junction and the RS-T segment. In general character these changes were not unlike those that took place in the upper curve, but they were smaller and in the opposite direction. When the heart was flooded with saline

(Fig. 2 *H*) and subsequently dried (Fig. 2 *J*), the size of both curves changed in the same manner as before. These procedures had no effect upon the general outline of either. When an electrode with a bare wick was substituted for the rubber-tipped x-electrode, flooding the heart produced a much greater reduction in the amplitude of the monophasic curve than it had before, but there was no other material difference.

In several experiments we studied the changes that occur in the responses of injured heart muscle with the lapse of time. It is, of course, well known that the monophasic responses produced by injuring the heart are transient. We wished particularly to determine whether T-wave changes similar to those seen in coronary occlusion occur when displacement of the RS-T segment produced by injuring the turtle's heart subsides. Because pronounced variations in the form of the T deflec-

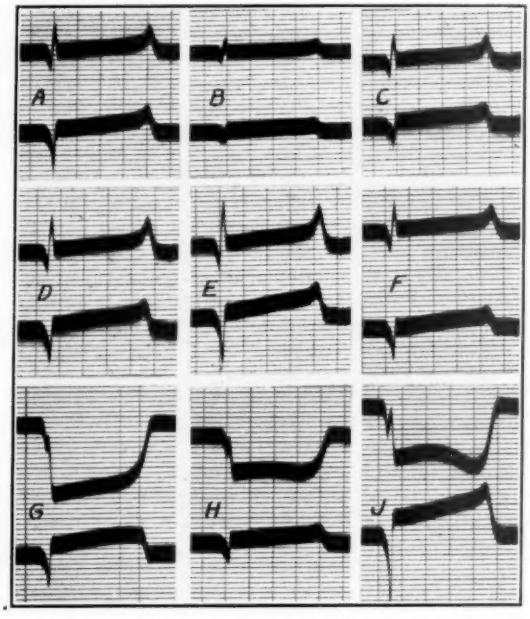

Fig. 2.—Experiment II. Exploring electrodes on ventral surface of turtle's ventricle. Indifferent electrodes on tail. Ordinate scale; records *A* and *B*, 5 mv. per centimeter; other records, 2.5 mv. per centimeter. *A*, control; *B*, after immersing heart in 0.9 per cent NaCl; *C*, after doubling sensitivity of both galvanometers; *D*, fluid draining away; *E*, remaining fluid removed and heart dried; *F*, second control; *G*, after burning tissue beneath x-electrode (upper curve); *H*, heart again immersed in saline; *J*, excess fluid removed and heart dried.

tion often occurred without obvious cause, we found it impossible to answer this question with certainty. Subsequent observations (Wilson, Johnston, Hill and Grout[5]) on dogs suggest that the inversion of the T deflection that follows elevation of the RS-T segment in clinical coronary occlusion is due to phenomena that take place at the margins of the infarcted area, and is not comparable to the minor T-wave changes that we sometimes observed after the disappearance of RS-T displacement produced by burning the surface of the cold-blooded heart.

Experiment III. The turtle was placed on its back in a shallow dish containing Ringer's solution, and the indifferent electrodes were 16 cm. from the heart. Both exploring electrodes were in contact with the ventral surface of the ventricle, the

x-electrode well toward the left, and the y-electrode on the right side. After taking a control record (Fig. 3 *A*) the exploring electrodes were temporarily removed, and the basal portion of the dorsal ventricular surface was burned. The curves taken immediately after replacing the electrodes in their original positions show a definite upward displacement of the RS-T junction and the RS-T segment (Fig. 3 *B*); in the upper curve this displacement is conspicuous, in the lower it is comparatively small. Subsequent records showed a gradual decrease in the displacement (Fig. 3 *C*), and after the lapse of fifteen minutes it practically disappeared. No further change occurred during the next half-hour (Fig. 3 *D*). At the end of this period the dorsal surface of the ventricle was burned again and over a slightly larger area than before. As a result the RS-T displacement returned (Fig. 3 *E*). No T-wave changes similar to those that are seen in myocardial infarction occurred.

Experiment IV. In some of the experiments in which one exploring electrode was directly in contact with the injured area the disappearance of the downward RS-T

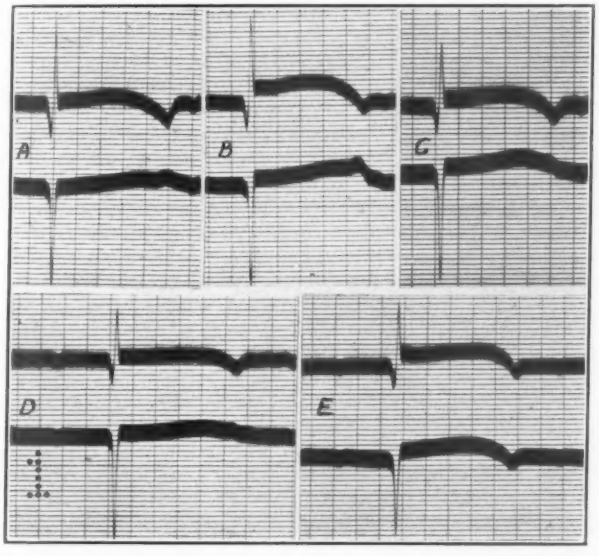

Fig. 3.—Experiment III. Exploring electrodes on ventral surface of turtle's ventricle. Indifferent electrodes 16 cm. from heart. Ordinate scale; 5 mv. per centimeter. *A*, control; *B*, after burning dorsal surface of ventricle; *C*, nine minutes after burn; *D*, forty-five minutes after burn; *E*, after second burn on dorsal surface.

displacement produced by the injury in the corresponding curve was accompanied by the development of a sharp upward movement at the end of the ventricular complex. This phenomenon is shown in the records reproduced in Fig. 4. In this experiment the heart was exposed by trephining the plastron, and the indifferent electrodes were placed within the trephine opening about 2 cm. from the heart. The exploring electrodes were in contact with the ventral surface of the ventricle, the x-electrode near the left margin of its basal, and the y-electrode near the right margin of its apical portion. After taking a control record (Fig. 4 *A*) a small area beneath the x-electrode was burned. The upper curve promptly became monophasic, and the lower showed a very slight elevation of the RS-T segment (Fig. 4 *B*). The monophasic deflection of the upper curve rapidly decreased in size (Fig. 4 *C*), and the initial deflections of the ventricular complex gradually regained their former shape (Fig. 4 *D*, *E* and *F*). In the control record the T deflection of the upper

curve ended in a distinct downward movement, but as the RS-T displacement of this curve diminished, a sharp peak developed at the point where this dip had formerly occurred (Fig. 4 *E*). The development of this peak was accompanied by the appearance of a simultaneous depression in the lower curve. In the last records (Fig. 4 *F*) this depression is not present, but it is possible that the position of the y-electrode shifted slightly during the latter part of the experiment. Although the T-wave change in this and in other similar experiments was in the same direction as that which occurs in coronary occlusion, it is doubtful whether it had a similar origin.

DISCUSSION

Apart from a slight difference in magnitude, the variations in potential at a given point on the ventral surface of the beating heart, when that surface is exposed to the air, are similar in all respects to the variations in potential in the immediate neighborhood of the same point when

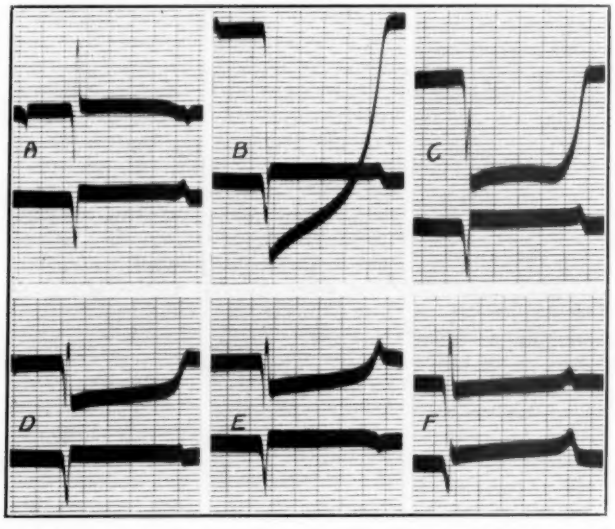

Fig. 4.—Experiment IV. Exploring electrodes on ventral surface of turtle's ventricle. Indifferent electrodes about 2 cm. from the heart. Ordinate scale; 5 mv. per centimeter. *A*, control; *B*, immediately after burning muscle beneath x-electrode (upper curve); *C*, four minutes after burn; *D*, fourteen minutes after burn; *E*, one hour after burn; *F*, four hours, forty-two minutes after burn.

the heart is completely surrounded by conducting material. In experiments of the kind under consideration it is certainly legitimate to neglect the potential variations of the distant electrode when the exploring electrode is very close to a portion of the heart's surface that is immersed. This cannot be denied without asserting that the laws which define current flow in volume conductors are invalid. We see no reason for considering the distant electrode appreciably less indifferent when the exploring electrode is in contact with a part of the heart's surface that is exposed to the air. We shall therefore assume that in all of our experiments the indifferent electrodes were at zero potential throughout the cardiac cycle.

If the potential of the distant electrode was not significantly affected by the heartbeat, the monophasic responses obtained in our experiments must be regarded as representing the potential of the exploring electrode and hence of the injured or dead muscle in contact with it.*

If we adopt the language of the membrane theory, we may say that when a small spot on the surface of the heart has been burned, the cell membranes of the superficial layers of muscle which have been killed are completely depolarized. We may assume that this dead tissue is bounded by a zone of injury in which the cell membranes are partially depolarized, and that the muscle beyond this zone is in no way affected. Any difference in potential between our electrodes produced by the current of injury may be neutralized. So far as the particular lead we are using is concerned this procedure restores the electrical conditions that prevailed before the injury. By compensating the injury current we have in effect repolarized the dead and injured tissues to the original intensity. The injury can now have no effect upon the potential difference between our electrodes until an excitation wave reaches the injured region. When the excitatory process spreads over the heart, partial or complete depolarization of the uninjured cell membranes takes place, and we shall assume that the resulting change in the electromotive force across these membranes is everywhere uniform. The excitation wave cannot, however, alter the electromotive force across the cell membranes that have been destroyed; in the zone of injury the degree of depolarization produced by its arrival may vary from zero to normal.

The injury cannot modify the electrical effects produced by the excitation of parts of the heart that it does not involve. When the exploring electrode is in contact with the ventricle, the chief upstroke or intrinsic deflection of the curve obtained signals the arrival of the excitatory process at the subjacent epicardial surface (Lewis and Rothschild[7]). Since a local injury can have no effect upon the action current until the excitation wave reaches the injured region, the deflections of this curve that precede the chief upstroke are not changed by superficial injuries affecting the muscle immediately beneath the exploring electrode.

*Physiologists have usually obtained curves of this kind by placing both electrodes upon the epicardial surface, one upon an uninjured and the other upon an injured region. Failing, for the most part, fully to appreciate that the potential of an electrode on the heart is affected not only by the excitation of the muscle immediately in contact with it, but also by the excitation of every other part of the heart, they have generally assumed that because dead muscle can produce no action currents, the potential of the latter electrode does not change. They have therefore regarded the curve obtained as representing the potential variations of the electrode in contact with uninjured muscle. Since the potential of a given point can be measured only with reference to that of some other point, one is at liberty to choose the standard of reference that is most suitable for his purpose. In studying an electric field it is, however, conventional to define the absolute potential of any point in the field as its potential with reference to that of a point outside the field (Attwood[8]). For many reasons, some of which we have already given, we have found it desirable when studying the electric field produced by the heartbeat to choose as our zero the potential of a point as far from the heart as possible.

The most striking effects of a fresh injury occur during the period immediately after all the uninjured cardiac muscle has passed into the excited state. Assuming that the current of injury has been neutralized, the potential of the exploring electrode at this time must be the same as it would be if the cell membranes of the dead muscle remained in the resting and fully polarized state and those of the injured muscle were only partially depolarized. The excitation wave is blocked at the boundaries of the injured tissue. The electric forces produced by its spread at the moment when, and in the region where, block occurs persist unaltered until they are extinguished by the return of the excited muscle to the resting state.*

It is possible to obtain a more exact idea of the electrical situation in the following way: Consider the zone lying between the two surfaces which separate the injured muscle from the dead muscle on the one side

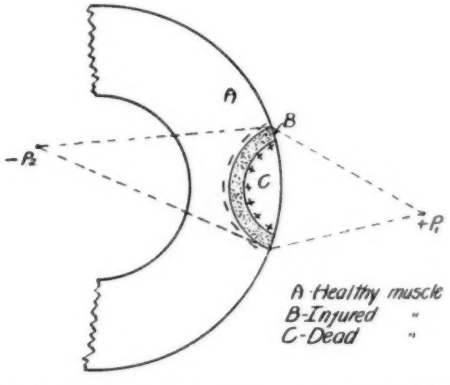

Fig. 5.—Diagrammatic representation of the electric field produced by an injured section of the ventricular wall at the end of the QRS interval. This field is similar to the one that would be produced if the injured muscle (dotted zone) were polarized in the sense indicated. If the exploring electrode were placed at P_1, the RS-T displacement would be downward; if this electrode were placed at P_2, the displacement would be upward.

and from the uninjured muscle on the other. Imagine that each fiber element within this zone is polarized in such a sense that the end nearest the dead muscle is positive and the end nearest the uninjured muscle negative. Imagine further that the intensity to which each element is polarized is equal to the difference between the change in the intensity of polarization of the cell membranes of that element actually produced by the spread of the excitation wave over it and the change that would have been produced if no injury had occurred. The electric field produced by this polarized zone (see diagram, Fig. 5) will then be identical with the one that occurs at the end of the QRS interval when the excita-

*Displacement of the RS-T segment may, of course, occur even when the injury is not severe enough to cause block. It becomes maximal when block is produced. For the production of this phenomenon it is essential that, in the region affected, the change in the intensity of membrane polarization produced by excitation shall be less than elsewhere. Whether a current of injury is or is not flowing is immaterial.

tion wave has been blocked at the boundary of the injured region.* For many purposes we may neglect the width of the zone specified and replace it by a single polarized surface lying between the injured and the uninjured tissue. At each point of this surface the intensity of polarization must be such as to make the drop in potential across it equal to the drop in potential across the corresponding portion of the polarized zone, and this in turn must be equal to the difference between the change in the electromotive force across the cell membranes produced by excitation on one boundary of this zone and that produced on the other. The character of the electrical field that would be produced by such a polarized surface has been discussed elsewhere.[3] For our present purpose we may regard the potential at a given point as roughly proportional to the product of the intensity of polarization† and the solid angle subtended at that point by any surface having the same boundaries or edges as the one specified (Wilson, Macleod and Barker[3]).

For a short period immediately following the QRS interval we may therefore expect the potential of the exploring electrode to be the same as it would be if the surface separating injured and uninjured muscle were polarized in the sense and to the intensity designated. If the exploring electrode is in contact with the injured area, the displacement of the RS-T segment will be downward; and if the surface of contact between the heart and the electrode lies wholly within the boundaries of the injured area, the size of the latter will have little or no effect upon the amount of displacement. If the heart is immersed in a conducting fluid and the exploring electrode is gradually moved away from the injured region along a line perpendicular to the surface of the heart, the solid angle subtended at the electrode by the polarized surface specified will decrease and the downward displacement of the RS-T segment must diminish. It should decrease much more rapidly when the injured area is small than when it is large. In order to produce RS-T displacement when the exploring electrode is at a considerable distance from the heart a large area of injury is necessary. If the injury is on the epicardial surface and the exploring electrode is on the opposite side of the heart, the solid angle subtended at this electrode by the polarized surface specified will be negative and the RS-T displacement will be upward.

By appropriate means a grade of injury insufficient to kill the muscle most seriously affected may, of course, be produced. If the excitation wave is not prevented from reaching this muscle, the drop in potential across the postulated surface between injured and uninjured muscle

*See Wilson, Macleod and Barker.[3]

†To avoid unnecessary complications we assume that the intensity of polarization over the surface in question is uniform. The fact that this is not necessarily the case does not affect the conclusions here set forth.

will not be so great as it would be if block occurred. The RS-T displacement cannot be maximal and a pure monophasic response cannot occur unless the injury is of sufficient grade to make it impossible for the excitation wave to reach the most severely injured tissue. If the injury is slight, the RS-T displacement will be slight; other factors being equal its magnitude should be proportional to the effect, in the zone where it is most intense, upon the change produced by excitation in the electromotive force across the cell membranes.

Only fresh injuries produce RS-T displacement. Within a short but variable time conditions similar to those that obtained before the injury are reestablished. The fatally injured muscle dies; some of the damaged cell membranes recover; new membranes may perhaps form. During this period of recovery the curves obtained are similar in every way to those that would be obtained if the grade of injury gradually grew less. The electrical effects produced by the tissue that has been killed are, of course, permanently lost.

SUMMARY

When an electrode at a distance from the heart is paired with an exploring electrode in contact with the ventricular surface, the curve obtained represents the potential variations of the latter. By comparison the potential variations of the former are so small that they may be neglected.

The curve obtained from a given point when the ventricular surface upon which the exploring electrode is placed is exposed to the air is larger but similar in all other respects to that obtained from the same point when the heart is completely surrounded by a conducting medium.

When the muscle beneath the exploring electrode is injured, pronounced displacement of the RS-T segment occurs and the ventricular complex often becomes monophasic. If the connections have been made so that relative negativity of the exploring electrode produces an upward deflection, the direction of this displacement is downward. When the subepicardial muscle is injured over a large area and the injury and the exploring electrode are on opposite sides of the heart, the displacement is upward and is less pronounced.

At the time when the displacement is maximal the electric field about the heart is similar to the one that would be produced if the surface between the injured and the uninjured muscle were polarized in such a sense as to make the injured muscle positive. A local injury on the epicardial surface does not alter the action current produced by portions of the heart that the injury does not involve. In any lead the deflections that are written before the excitation wave reaches the injured region are of the same form after the injury as before. The RS-T displacement produced by burning the surface of the cold-blooded heart quickly

subsides and is not, apparently, followed by T-wave changes of the kind that occur when the mammalian heart is injured by coronary ligation.

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THE INTERPRETATION OF THE GALVANOMETRIC CURVES OBTAINED WHEN ONE ELECTRODE IS DISTANT FROM THE HEART AND THE OTHER NEAR OR IN CONTACT WITH THE VENTRICULAR SURFACE*

Part II. Observations on the Mammalian Heart

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Introduction.—The observations reported here supplement those described in Part I.‡ The point of view is fundamentally the same, but the method of analysis is different. Our present purpose is to discuss certain relations between the potential variations that occur at or near the epicardial surface of the mammalian heart and those that take place inside the ventricular cavities. Our investigation of this subject was prompted by the observation that when the anterior wall of the heart is infarcted, the ventricular complexes in precordial leads are similar to those obtained when the exploring electrode is placed opposite one of the valvular orifices of the normal heart.[1] We suspected that in both cases the ventricular complexes were of the kind that would be obtained by placing this electrode inside the ventricular cavity.

Methods.—Practically all the observations discussed on the following pages were made more or less incidentally in the course of a series of experiments in which our main object was to study the electrocardiographic changes produced by infarction of the myocardium. The dogs used had previously been subjected to an operation in which coronary ligation was performed or attempted. There is, however, no reason to believe that different results would have been obtained if normal animals had been used. We shall consider no observations upon which the previous interference or attempted interference with the coronary circulation could conceivably have a bearing. Unless otherwise noted all observations were made after exposing the heart by splitting the sternum and opening the pericardial sac. Standard Lead I was taken simultaneously with all direct and semidirect leads. The latter were taken with the galvanometer responsible for the lower curve, and this galvanometer was connected to the plate circuit of a vacuum tube as in the case of the turtle experiments described in Part I.

The indifferent electrode was usually placed upon the left hind leg; in a few experiments a central terminal, connected to the two forelegs and to the left hind leg through resistances of 5,000 ohms, served as the indifferent point.[2] For direct leads the string tension was adjusted to give a deflection of one-half centimeter when a potential difference of ten millivolts was introduced into the input circuit.

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‡See page 163.

When semidirect leads were taken, the deflection per millivolt was greater, but the galvanometer sensitivity varied with the position of the exploring electrode. The exploring electrodes used were similar to those employed in our turtle experiments (Part I), except that in most instances the wick was replaced by a small piece of sponge. To obtain records of the potential inside the ventricular cavities we employed an electrode that could be thrust through the heart wall. This stab-electrode, which was also useful in studying the responses of injured heart muscle, consisted of a piece of heavy copper wire, about three inches long, sharpened at the end. Enamelled wire was used and the insulation was left intact to within approximately one millimeter of the point. Because of the high resistance in the input circuit of the vacuum tube this electrode did not polarize.

Illustrative experiment.—The curves reproduced in Fig. 1 are from an experiment (Experiment 45) in which a stab-electrode was pushed through the skin, in the fifth intercostal space 6 cm. to the left of the

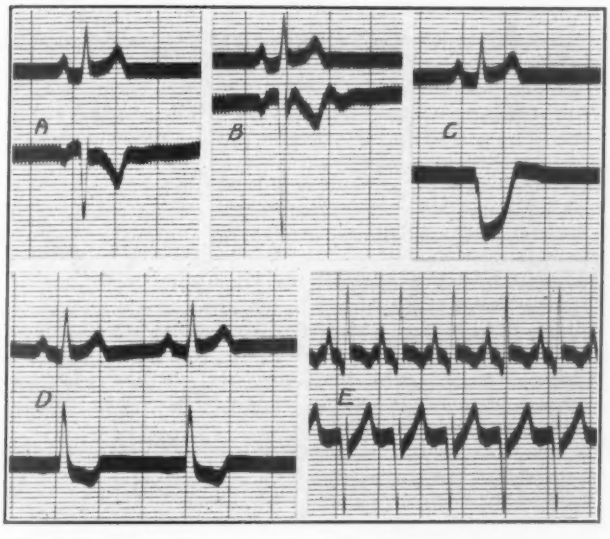

Fig. 1.—Experiment 45. Upper curve represents standard Lead I in all records. Lower curves obtained by pushing a sharp electrode, insulated to the tip, through the skin of the precordium (fifth interspace) and thrusting it deeper step by step until it entered the cavity of the left ventricle. A central terminal (see text) served as the indifferent point. *A*, electrode 0.75 cm. beneath the skin; *B*, electrode 2 cm. beneath the skin; *C*, electrode 3.75 cm. beneath the skin and just touching the heart; *D*, electrode 4.6 cm. beneath the skin and inside the cavity of the left ventricle. Ordinate scale of lower curves: *A* and *B*, 2 mv. per centimeter; remaining curves, 20 mv. per centimeter. In all experiments the connections were so made that negativity of the exploring electrode produced an upward deflection.

midline, and thrust step by step through the underlying tissues until it entered the cavity of the left ventricle. This procedure was carried out after the animal had been fully anesthetized and while the chest was intact. The indifferent point was a central terminal of the kind already described. Curves were taken when the uninsulated point of the electrode was 0.75 cm. beneath the skin (Fig. 1 *A*), 2.0 cm. beneath the skin (Fig. 1 *B*), 3.75 cm. beneath the skin and just touching the heart (Fig. 1 *C*), and 4.6 cm. beneath the skin and in the cavity of the left ventricle

(Fig. 1 *D*). For the first two curves the galvanometer sensitivity was one-half normal; for the last two it was one-twentieth normal. The chest was then opened, and when the heart was exposed, the puncture wound made by the sharp electrode was easily located on the anterior surface of the left ventricle about 1 cm. below the interventricular groove. A curve was then taken with a sponge-tipped exploring electrode placed directly over this point (Fig. 1 *E*).

These curves are of interest from several points of view. We may call attention, first of all, to the close resemblance in general outline between the initial ventricular deflections of the curves taken when the stab-electrode was still some little distance from the heart and the initial deflections of the curve taken from the region of the puncture wound after the heart had been exposed. The T deflections of the former curves and those of the latter are quite unlike, but this is not surprising since it is known that the T deflection is easily modified by many factors. When the stab-electrode came in contact with the heart, the resulting injury, which must have involved a very small amount of muscle, gave rise to a monophasic ventricular complex. Because the injured area was smaller than the surface of the sponge-tipped electrode, and also perhaps because of the lapse of time, no definite RS-T displacement was observed when this electrode was later placed in contact with the wound.

The potential of the ventricular cavities.—The curve from the left ventricular cavity (Fig. 1 *D*) is smaller in amplitude but otherwise similar to those obtained from this cavity in experiments in which the heart had been exposed. The main upstroke occurs very early and is not preceded, as is invariably the case in epicardial curves, by a downward movement. It is less abrupt and of longer duration than the intrinsic deflections of epicardial leads. The T deflection is represented by a rounded depression. The curves obtained from the cavity of the right ventricle frequently show a small initial dip; in other respects they are similar to those obtained from the cavity of the left.

The curves reproduced in Fig. 2 (*A, B, C,* and *D*), represent the potential variations of the two ventricular cavities before and after the left branch of the His bundle was cut (Experiment 26). Between the two curves taken before branch block was produced there is only one important difference; the main upstroke of the right ventricular curve (Fig. 2 *A*) is preceded by a small inverted peak, but the left ventricular curve (Fig. 2 *C*) shows no more than a mere trace of such a deflection. When the bundle was cut the former curve lost its inverted peak (Fig. 2 *B*), and the latter developed a large downward movement (Fig. 2 *D*), which completely altered its appearance. In experiments in which the right branch of the His bundle had been cut the right ventricular curve

began with a large downward movement (Fig. 2 *E*), and the first deflection of the left ventricular curve was upward (Fig. 2 *F*).

We believe that these observations have an important bearing upon the interpretation of all curves obtained by placing the exploring electrode near or in contact with the epicardial surface. The electromotive force produced by the excitation wave as it spreads over the ventricular walls from within outward tends to make the ventricular cavity negative and the epicardial surface positive. The magnitude of the electromotive force generated by any section of the ventricular wall at a given instant is measured by the difference between the electromotive force across the cell membranes of the innermost and the electromotive force across the cell membranes of the outermost layers of muscle (Wilson, Macleod

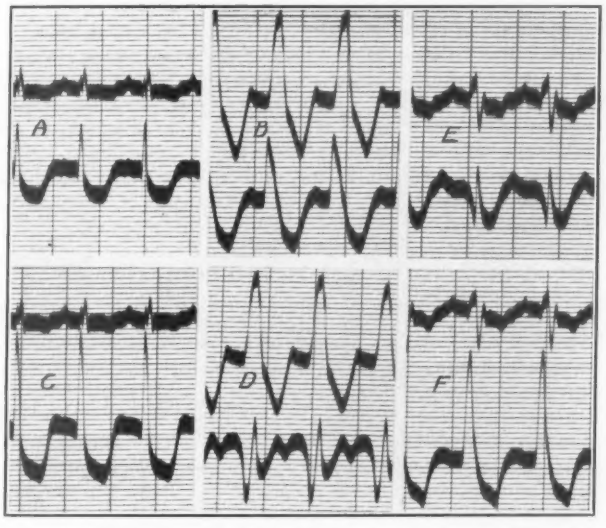

Fig. 2.—Upper curve represents standard Lead I. Lower curves as follows: Potential of right ventricular cavity before (*A*) and after (*B*) cutting the left branch of the His bundle. Potential of left ventricular cavity before (*C*) and after (*D*) cutting left branch of His bundle. Potential of right (*E*) and potential of left (*F*) ventricular cavity after cutting the right branch of the His bundle. The last two curves are from Experiment 50; the others are from Experiment 28. In both these experiments a central terminal served as the indifferent point.

and Barker[3]). Before activation of the subendocardial muscle begins and after activation of the subepicardial muscle is completed, the electromotive force across the ventricular wall is zero. It increases rapidly when the excitation reaches the endocardial and decreases rapidly when it reaches the epicardial surface. Throughout the QRS interval the electric field about the heart is equivalent to that which would be produced if the zone of muscle undergoing activation were polarized in such a way as to produce an electromotive force between its boundaries equal to that generated by the corresponding portion of the ventricular wall.[3]

The curve from the left ventricular cavity reproduced in Fig. 1 *D*

represents the potential at a point a little less than 1 cm. away from the puncture wound on the epicardial surface. Nevertheless its initial deflections are very different from those obtained, after the heart had been exposed, by placing the exploring electrode directly over this wound. If we may neglect the effect of exposing the heart upon the electric field in this neighborhood, we may say that throughout the period when the potential of the epicardial surface was positive, that of the nearest part of the ventricular cavity was negative.

We believe that all the major differences between the initial deflections of the two curves in question must be ascribed to the effect of the electromotive forces generated by the activation of that section of the ventricular wall through which the stab-electrode passed. This opinion is based, first of all, upon the character of the laws that define the flow of electric currents in volume conductors.[3] Electromotive forces generated in other parts of the heart might easily produce a difference in potential between two electrodes on opposite sides of the lateral wall of the left ventricle and approximately 1 cm. apart. It would be practically impossible for such forces to make one of these electrodes negative and the other positive with respect to a point distant from the heart. The initial deflections in Fig. 1 *E* are, as we have already pointed out, strikingly similar in general outline to those in Figs. 1 *A* and 1 *B*, which represent the potential at two points, one approximately 1.75 cm. and the other 3 cm. from the puncture wound. The potential variations that occurred at these points during the QRS interval differed only in magnitude from those that took place at the epicardial surface. The reason must be that between these points and the epicardial surface there was no cardiac muscle generating an electromotive force. Finally, it was found in the course of our observations on experimental myocardial infarction that when a section of the ventricular wall has been killed, the curves obtained by leading from the epicardial surface and those obtained by leading from the nearest part of the ventricular cavity are practically identical in form.[4] It is, therefore, clear that the potential of a point just inside and that of a point just outside a given part of the ventricular wall vary in a similar way when no electromotive force is being generated by the muscle between them.

When the excitation wave has spread over most of the subendocardial muscle of the left ventricle, we may think of the cavity of this ventricle as surrounded by a zone of muscle undergoing activation and producing effects similar to those that would occur if it were electrically polarized. For most purposes the width of this zone may be neglected, and it may be regarded as a polarized surface. At any instant during the QRS interval there must be in this polarized zone or surface certain windows or openings: an opening corresponding to each of the valvular orifices; to each region where the subendocardial muscle has not yet been acti-

vated; and to each region where the whole thickness of the ventricular wall has passed into the excited state. Throughout the QRS interval, points in the ventricular cavity lie on the negative side of the polarized zone and display a negative potential. The potential of a point on or near the epicardial surface and opposite a window must be similar to that of the neighboring part of the ventricular cavity. We may therefore expect an exploring electrode that is on or near the epicardial surface to be either at zero potential or negative with respect to a distant point until the subendocardial muscle of the subjacent wall is activated. When activation of this muscle begins, the potential of this electrode will rapidly become less negative or more positive; as soon as this muscle is fully active it will be strongly positive. When the excitation wave reaches the subepicardial muscle, the potential difference between the epicardial surface and the ventricular cavity will rapidly decrease; when this muscle is fully active, it will practically disappear, and the exploring electrode will again be either negative or at zero potential with respect to an indifferent point.

In this discussion we have, for the sake of simplicity, neglected the effects produced by the simultaneous spread of the excitation wave through the walls of the right ventricle. The cavity of this ventricle will likewise be surrounded by a polarized zone or surface, which must produce an electric field and affect the potential of points on the epicardial surface of the left ventricle as well as elsewhere. When both sides of the septum are activated simultaneously, however, we may neglect the effects produced by it, and regard the two polarized surfaces as forming a single surface surrounding both ventricular cavities. If the two sides of the septum are not activated simultaneously, the matter is more complicated. In bundle-branch block the cavity of the homolateral ventricle lies outside the polarized zone which surrounds the cavity of the contralateral ventricle, and is therefore positive until the excitation wave has pierced the septum. The inverted peak that usually precedes the main upstroke in curves from the right ventricular cavity of normal animals apparently means that the left side of the septum is ordinarily excited in advance of the right.

Epicardial curves.—We may now apply the principles outlined to the interpretation of the more common types of initial ventricular deflections obtained by leading directly from the epicardial surface. Examples of these are shown in Fig. 3 (*A, B, C,* and *D*). Leads from the central portion of the anterior surface of the right ventricle, where the muscle is thin, usually yield curves which show a small downward movement followed by the intrinsic deflection,[5] which rises far above the baseline (Fig. 3 *A*). We ascribe the downward movement to the electrical effects produced by the passage of the excitation wave outward through the thin

wall.* As soon as the subepicardial muscle beneath the exploring electrode has become fully active, this electrode assumes the potential of the ventricular cavity which at that instant (very early in the QRS interval) is strongly negative.

It is true that the onset of the intrinsic deflection marks the arrival of the excitation wave at the epicardial surface.[5] This deflection is not, however, due to electric forces produced by and originating in the muscle beneath the exploring electrode. If the excitation wave were not spreading on the opposite side of the ventricular cavity, the complete activation of this muscle might permit the string to return to the baseline, but could not carry it beyond. The electric forces that make the exploring electrode strongly negative and raise the intrinsic deflection above the

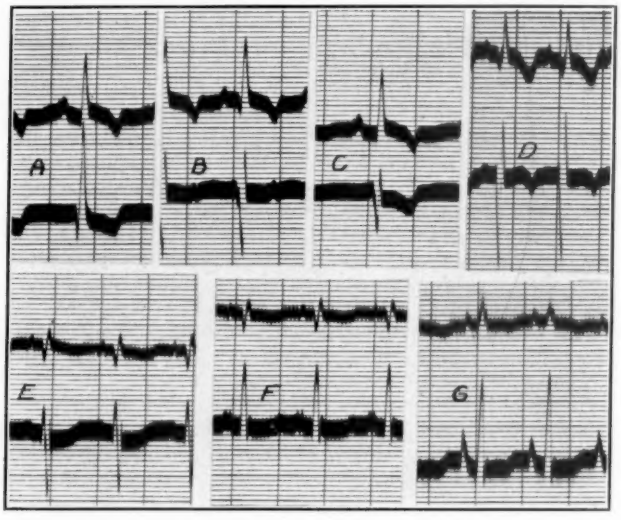

Fig. 3.—Upper curve represents standard Lead I in all records. The data given below refer to the lower curves only.

Records of upper row: Exploring electrode on the epicardial surface. *A*, exploring electrode on right ventricle (central region); *B*, on left ventricle (near interventricular sulcus); *C*, on left ventricle (central part of ventral surface); *D*, on left ventricle (near apex). The first three of these curves are from Experiment 50, in which a central terminal served as the indifferent point. The last one is from Experiment 32 in which the indifferent electrode was on the left hind leg. Ordinate scale: 20 mv. per centimeter.

Records of lower row. Curves from an experiment, performed in January, 1930, in which the indifferent electrode was placed on the left hind leg. *E*, exploring electrode on conus arteriosus just below pulmonary valve; *F*, exploring electrode on pulmonary artery just above pulmonary valve; *G*, exploring electrode in cavity of right auricle. Ordinate scale: for *E*, 10 mv. per centimeter; for *F* and *G*, 5 mv. per centimeter.

zero level are the same as those that make the ventricular cavity strongly negative. These forces originate, for the most part, in muscle distant from the exploring electrode.

*The same forces that produce the initial downward movement in curves from the right ventricular cavity may contribute in some small measure to the formation of this deflection.

In curves from the thicker portions of the right and from the greater part of the left ventricular surface the intrinsic deflection is preceded by a downstroke that is much deeper and of longer duration (Fig. 3 *B*). The greater duration of this deflection, in comparison with those obtained from thin portions of the ventricular wall, is clearly due to the increased time required by the excitation wave to spread from the endocardial to the epicardial surface. Its greater depth may be due to several causes. Up to a certain point an increase in the thickness of the ventricular wall may tend to increase the electromotive force which it develops during activation. Excitation is not instantaneous, but requires a short interval of time. When the time required by the excitation wave to cross the ventricular wall becomes greater than the time necessary for complete activation of a single muscle element to take place, the endocardial surface must become fully active before activation of the epicardial surface begins, and the electromotive force between the two surfaces must reach its maximal value. It should be remembered, however, that the electromotive force across the ventricular wall is approximately equal to the difference in potential between the cavity and the epicardial surface. Early in the QRS interval the ventricular cavity is strongly negative; an electromotive force across the ventricular wall sufficiently large to produce a small downward deflection in a given epicardial lead at this time would produce a much larger one later when the negativity of the ventricular cavity is less pronounced. Intrinsic deflections that occur late do not rise far above the baseline because the potential of the ventricular cavity is then approaching zero. At a time when the potential of the cavity is not changing rapidly, the height of the intrinsic deflection, measured from the point below the baseline where it begins to the point above the baseline where it ends, may be taken as a rough measure of the electromotive force that existed across the ventricular wall immediately before its onset.

From some parts of the left ventricle, less often from parts of the right, curves are sometimes obtained in which the downward movement produced by the outward progress of the excitation wave is preceded by a small summit (Fig. 3 *C* and *D*). An unusually large deflection of this kind is shown in Fig. 3 *E*. This curve was obtained by leading from the epicardial surface of the conus arteriosus just below the pulmonary valve. The curve shown in Fig. 3 *F* was obtained from the surface of the pulmonary artery just above the valve, and that reproduced in Fig. 3 *G* from the cavity of the right auricle. The last two are similar to curves from the ventricular cavities; they show no distinct downward movement preceding the main upstroke. In the one instance the exploring electrode was opposite the pulmonary orifice and in the other opposite the tricuspid orifice, and in both cases its potential apparently varied with that of the right ventricular cavity. When this electrode was placed on the

muscle of the conus (Fig. 3 *E*), its potential followed that of the cavity only until the endocardial surface became active.* It then became positive and remained so until the excitation wave reached the epicardial surface, at which time the usual intrinsic deflection occurred.

We attribute the occurrence of an initial upward deflection that precedes the chief downward movement in epicardial leads to late activation of the endocardial surface. We believe that the summit of this deflection occurs approximately at the time when activation of this surface begins. In rare instances this peak is preceded by a diminutive downward movement, and the cause of this preliminary dip is obscure except in those cases where a similar and simultaneous dip occurs in leads from the ventricular cavity.

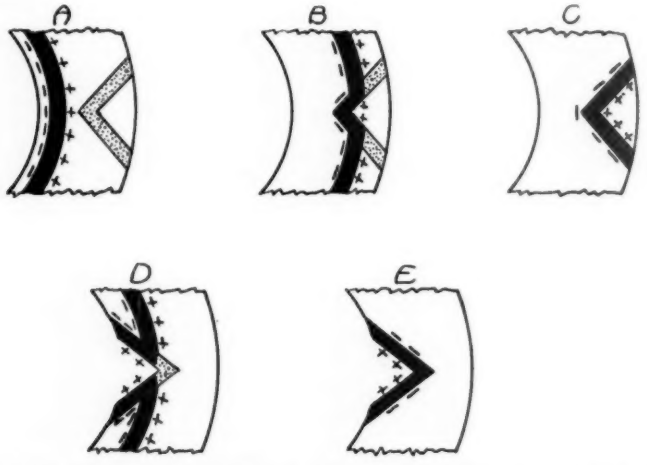

Fig. 4.—Diagrammatic representation of the electric forces generated by activation of a section of the ventricular wall that has been injured by pressing a sharp electrode against its epicardial (*A*, *B*, and *C*) or endocardial (*D* and *E*) surface. The dotted zone represents injured muscle (about the end of the sharp electrode) which the excitation wave has not yet reached. The black zone represents the uninjured muscle that is undergoing activation and the injured muscle which the excitation wave has reached and in which it has been blocked. Across this zone there is an electromotive force of the kind indicated. *A*, the electric forces early in the QRS interval before the excitation wave has reached the injured tissue; *B*, and *D*, just after the excitation wave has reached the injured tissue; *C* and *E*, at the end of the QRS interval when all of the uninjured muscle has passed into the excited state. For the sake of clarity the black zone has been made relatively narrow in comparison with the thickness of the ventricular wall; it is probably much wider than is here indicated.

The curves obtained when a sharp electrode is used.—Injuries that involve the subepicardial muscle over a small area have no appreciable effect upon the curves obtained by leading from the ventricular cavity; they have a very profound effect upon those obtained by leading directly from the region injured. When the curve reproduced in Fig. 1 *C* is compared with that shown in Fig. 1 *D*, it is clear that, in effect, the injury inflicted by the stab-electrode maintained throughout the greater part of systole the electromotive force generated across the subjacent

*In many animals leads from the conus yield curves in which the initial deflection is downward.

ventricular wall by the outward passage of the excitation wave. The reasons for this have already been given (Part I), but they may be restated in a somewhat different form. When the excitation wave is blocked at the boundary of the injured region, the effect is the same as if the muscle beyond the block were uninjured and remained in the unexcited state. The polarized zone which represents muscle undergoing activation spreads outward to the region of block and remains there until it is abolished by the return of the adjacent uninjured muscle to the resting condition (Fig. 4). At the end of the QRS interval, when all the uninjured muscle has been activated, the electromotive force across this zone is the same as if it were bounded on the outer side by

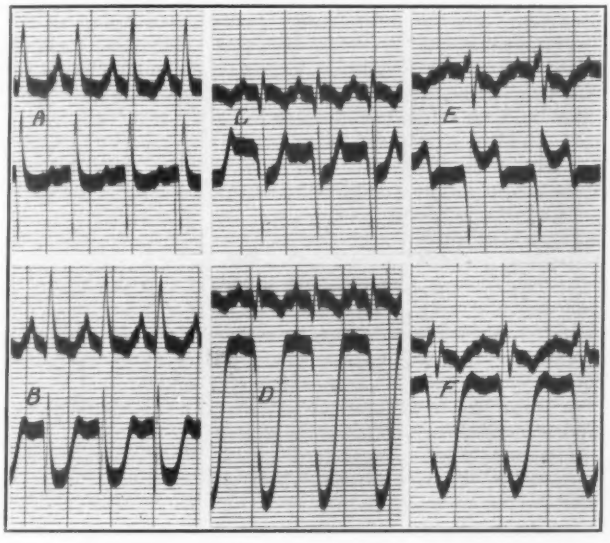

Fig. 5.—Upper curves represent standard Lead I in all records. The lower curves in the two records of each column were taken from the same or from neighboring points, one with a soft-tipped electrode (upper row) and the other with a sharp electrode (lower row). Ordinate scale: 20 mv. per centimeter. *A* and *B* are from the right central region (Experiment 15); *C* and *D* are from the ventral surface of the right ventricle, near the base (Experiment 11). *E* and *F* are also from the ventral surface of the right ventricle, near the base (Experiment 50) and were taken after the right branch of the His bundle had been cut.

resting and on the inner side by fully active muscle; it is therefore equal to the maximal electromotive force that the ventricular wall can generate between its two surfaces.

If the injury is not severe enough to cause block, it does not prevent the excitation wave from reaching the epicardial surface. It does not, therefore, abolish but merely reduces the decrease in the electromotive force across the ventricular wall that ordinarily follows this event. The effect is the same as if the subepicardial muscle could be partially, but not fully excited. The electromotive force across the polarized zone

bordering the injured muscle at the end of the QRS interval is then submaximal.

When two curves are taken from the same or from neighboring points on the epicardial surface, the first by means of a soft-tipped and the second by means of a stab-electrode, the ventricular deflections of the two curves are usually identical or nearly so up to the point where the intrinsic deflection begins (Fig. 5). The reason for this is obvious; as we have already pointed out (Part I), an injury cannot modify ventricular deflections that are written before the excitation wave reaches the injured tissue. The effect of the injury upon the intrinsic deflection varies with the grade of injury produced. With increasing grades of

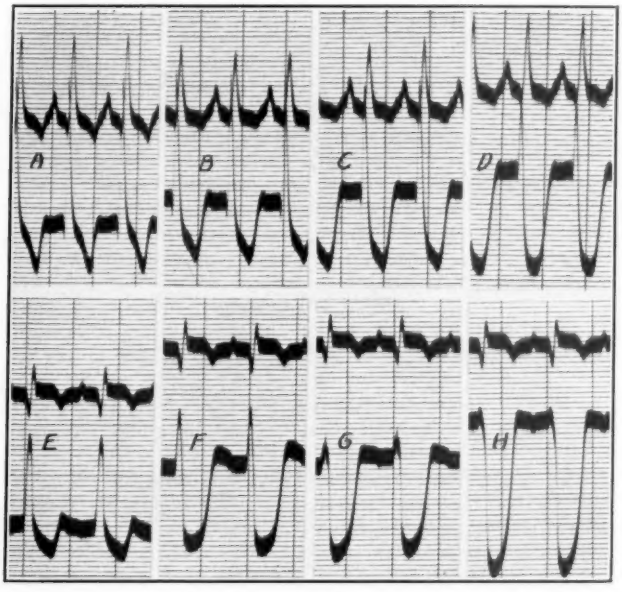

Fig. 6.—Upper curve standard Lead I throughout. Ordinate scale of lower curves: 20 mv. per centimeter. Upper row; *A*, from right central region with soft-tipped electrode; *B*, *C*, and *D* are from a nearby point and show the effect of using a sharp electrode and gradually pressing it more firmly against the heart (Experiment 45). Lower row: *E*, stab-electrode in left ventricular cavity (Experiment 44); *F*, point of electrode thrust into subendocardial muscle of dorsal wall; *G*, electrode thrust more deeply into dorsal wall; *H*, electrode thrust still more deeply into dorsal wall.

injury the sharp upward movement that constitutes this deflection becomes smaller and smaller; when the injury is sufficiently severe, it frequently disappears. The RS-T displacement also depends upon the grade of the injury, and presumably becomes maximal when the injury is sufficiently intense to block the excitation wave. A series of curves illustrating the effect of pressing a stab-electrode more and more firmly against the heart is shown in Fig. 6 (*A*, *B*, *C*, and *D*). These curves are from the central region of the right ventricle. The first (Fig. 6 *A*) was taken with a sponge-tipped electrode, the last three with a stab-electrode.

As the pressure upon the sharp electrode was increased, the intrinsic deflection became smaller and the RS-T displacement larger, and the increase in the latter was approximately equal to the decrease in the former (Fig. 6, *B*, *C*, and *D*).

When the intrinsic deflection rises high above the baseline, the injury inflicted by the stab-electrode seldom if ever abolishes it. Except during periods when the electromotive force across the ventricular wall is changing, the potential of a point on the epicardial surface and that of the neighboring portion of the ventricular cavity must vary together and in a similar way. When the curve from the ventricular cavity is rising, a curve from the epicardial surface must also rise unless the electromotive force across the intervening ventricular wall is increasing. Very soon after the excitation wave arrives at the zone of injury produced by a stab-electrode pressed against the epicardial surface, the electromotive force across the ventricular wall at this point must either diminish or become constant. If at that time the curve from the ventricular cavity is rising, the curve from the injured region must also rise. For this reason curves from an injured area on an epicardial region that normally displays an early intrinsic deflection almost always show a prominent notch or an upward movement early in the QRS interval.

We may look at this matter from another standpoint. As we have already pointed out, intrinsic deflections that rise above the baseline do so in response to electric forces originating in muscle distant from the region where they are recorded. An injury in this region cannot alter these forces. Nevertheless, if the injury is sufficient to block the excitation wave and does not involve the endocardial surface, so that the maximal electromotive force which the excitation wave is capable of producing is generated between the stab-electrode and the ventricular cavity, the upward movement produced by these distant forces should theoretically fail to carry the string beyond the zero level. Intrinsic deflections of the kind under consideration are, however, usually obtained in regions where the ventricular wall is thin, and it is possible that any injury sufficiently intense to block the excitation wave usually causes some depolarization of the cell membranes on the endocardial surface. This would tend to prevent the electromotive force across the ventricular wall from reaching its maximal value, and might make it impossible for the injury either to prevent the intrinsic deflection from rising above the baseline or to produce maximal RS-T displacement. When all the muscle lying between the electrode and the endocardium is killed, the potential of the exploring electrode is nearly the same as that of the ventricular cavity throughout the cardiac cycle.[4] This situation often arises in myocardial infarction, both in animals and in man.

Curves of an interesting type are obtained when the stab-electrode is pushed through the ventricular cavity into the subendocardial muscle of

the posterior wall or of the septum. The first deflection of these curves is a prominent summit (Fig. 6 *F*), which becomes smaller if the electrode is pushed more deeply into the muscle (Fig. 6 *G* and *H*). Curves of the same kind are obtained if the electrode is thrust into the ventricular cavity and then withdrawn until its uninsulated point is beneath the endocardium. The potential of the electrode naturally varies with that of the ventricular cavity until the neighboring endocardial surface becomes active. Even after this the hole made by the electrode communicates with the cavity, and apparently acts as a window which cannot be closed by the polarized zone, which, according to our hypothesis, represents muscle undergoing activation. Since the point of the electrode lies opposite this window, its potential tends to follow that of nearby points inside the ventricle. When the electrode is pushed deeper, the window is farther from its point and therefore less effective.

A pure monophasic response showing no notches on its descending limb is rarely obtained from the mammalian heart except from epicardial regions where the curve obtained with a soft electrode is of the type that begins with a deep downward movement and displays an intrinsic deflection which does not rise far above the zero level. From such regions, however, pure monophasic responses are obtained without special difficulty (Fig. 5 *D*). They often show a slight thickening on the descending limb at the point where the intrinsic deflection formerly began. When the epicardial surface is injured by a stab-electrode at a point where the intrinsic deflection occurs late in the QRS interval, the excitation wave reaches the injured muscle at a time when the negative potential of the ventricular cavity is rapidly diminishing. Since the electromotive force across the ventricular wall must then have reached its maximum value, it must be constant or decreasing. If it is constant or if it is decreasing less rapidly than the negative potential of the ventricular cavity, the curve obtained continues to descend and shows no upstroke at the point where the intrinsic deflection is due.

SUMMARY

When the exploring electrode is placed in the left ventricular cavity of the dog's heart, the QRS group of the curve obtained is represented by a single deflection. The direction of this deflection is upward, indicating that the potential of this cavity is negative throughout the QRS interval. When this electrode is placed in the right ventricular cavity, the curve obtained is similar but may show a small preliminary dip preceding the main upstroke.

When the exploring electrode is placed on the epicardial surface, its potential is conspicuously different from that of the nearest portion of the ventricular cavity only during the period when the excitation wave is spreading outward through the subjacent ventricular wall. Before

the endocardial surface becomes active and after the epicardial surface has been fully activated, there is no electromotive force across the ventricular wall, and a lead from the epicardial surface is, in effect, a lead from the ventricular cavity.

The occurrence in an epicardial lead of an upward deflection which precedes the main downstroke is therefore attributed to late activation of the endocardial surface. The main downstroke is due to electric forces produced by the progress of the excitatory process outward through that portion of the ventricular wall lying between the exploring electrode and the ventricular cavity. The intrinsic deflection marks the arrival of the excitation wave beneath the exploring electrode, and hence the extinction of the electromotive force across the subjacent ventricular wall. The sudden upstroke which constitutes this deflection occurs as this electrode assumes the potential of the ventricular cavity.

The same principles may be applied to the interpretation of the curves obtained by placing the exploring electrode upon a portion of the ventricular surface of the dog's heart that has been injured. Pure monophasic curves may be obtained by means of such leads if the region injured is one where the intrinsic deflection occurs late and does not rise far above the zero level.

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FACTORS CONCERNED IN CARDIAC HYPERTROPHY

A Study Made at Necropsy of Seventy-Nine Cases of Rheumatic Heart Disease*

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THE problems of cardiac hypertrophy have been the basis of numerous investigations as recorded in the older as well as in the more recent medical literature. As early as 1877, Cohnheim experimentally produced aortic insufficiency in dogs, in order to study the effect of this lesion on the heart. His method, unfortunately, permitted only very short periods of observation, so that his experimental conditions were in no way comparable to the condition usually observed in man. A year later Rosenbach, a student of Cohnheim, carried out experiments on rabbits, producing aortic insufficiency in some and mitral insufficiency in others, demonstrating the occurrence of cardiac dilatation and hypertrophy. His experiments covered a longer period, and the conditions produced were more comparable to the chronic lesions seen in man.

Müller, in 1883, demonstrated similar experimental results by comparing the weight of the heart to that of the body. He also studied the auricular and ventricular weights differentially by separation, but his technic has been shown to be inaccurate in the light of more recent work.[17]

Tangl, in 1889, produced chronic aortic insufficiency experimentally which resulted in cardiac hypertrophy, and concluded that the degree of hypertrophy depended on the time that the lesion which caused regurgitation had existed, and on its degree, and also that an increase in size of the individual muscle fibers occurred. Numerous references, other than those mentioned, may be found in the literature.

It is interesting and appropriate to review some of the hypotheses that have been advanced regarding the causes of cardiac hypertrophy: (1) Since the early part of the nineteenth century,[5, 6, 25] increased work of the heart has been considered predominantly as the most important influence in the production of cardiac hypertrophy. (2) Possible increase in coronary blood flow as demanded by the increase in muscle mass has been suggested as a contributary influence.[19, 24] (3) The existence of inflammatory lesions of the myocardium was considered capable of producing cardiac hypertrophy.[1, 21] (4) An increase in in-

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terstitial myocardial tissue was believed to be a factor.[7, 16] (5) Prolongation of the midsystolic period and its consequent prolonged hyperemia and increased local nutrition were advanced as a cause.[15] (6) When the heart is subjected to overstrain, as occurs if a valvular lesion is present, the heart dilates, and in order to reestablish normal function, it must increase its force. The stimulus for this seems to lie in the residual blood in the ventricle, which acts as an increased load and tends to increase both the irritability and the force of contraction and to bring about an increase in tonicity.[9, 12] (7) More recently, Herrmann has stressed the importance of considering not one influence but a combination of influences in the production of cardiac hypertrophy.

The present study was undertaken to determine, if possible, the major factors and their relative importance in the development of cardiac hypertrophy in man.

MATERIAL

The material which formed the basis for this study comprised seventy-nine cases of rheumatic heart disease in which careful necropsy had been conducted. The cases were carefully selected, so that all the required data were available in every instance. The requirement for inclusion demanded an accurate record of the time of the initial illness with rheumatic fever, the patient's age, sex, body weight, and height, with special data regarding the departure of each from his average normal weight during health; also were required the weight of the heart, accurate description of the cardiac lesions, including associated pathological changes, the cause of death, and records of blood pressure. Patients who had hypertension or who presented evidence suggesting previous hypertension, were not included.

METHOD OF STUDY

The heart was removed from the body in the usual manner, opened and washed before weighing.

In order to permit comparative analysis the cases were grouped according to type of valvular lesion. The valvular defect, whether it was stenotic or allowed regurgitation, or both, was graded numerically on the basis of 0 (no defect) to 4 (extreme defect) for clearness and brevity. The predominant defect was always considered first, presuming its greater influence on cardiac hypertrophy. When the defect was limited to one valve and was of one type only, it was so considered; and when defects involved more than one valve, they were grouped as such. In the case of mitral endocarditis, the defects were uniformly of the stenotic type and of the type that allowed of regurgitation, the stenotic element universally predominating.

NORMAL CARDIAC WEIGHTS

In a study predominantly dealing with cardiac weights it is necessary clearly to expound the normal values utilized. The figures for normal cardiac weights are those established by one of us (Smith) in 1928, in a carefully conducted study of 1,000 normal hearts. These figures showed that the average weight of the heart of the adult males was 294 gm. (165 to 320 gm.), and that the average weight of the heart of adult females was 250 gm. (135 to 325 gm.). The data obtained in the

study made in 1928 demonstrated a definite correlation between the weight of the heart and the weight of the body, the ratios in adults of average weight were 0.43 per cent for males and 0.40 per cent for females. Among thin persons the ratio is slightly higher, whereas among obese persons it is slightly lower. These variations in individual habitus are important, and must always be considered in the computation of cardiac weights.

The same former study[20] also showed that the weight of the heart can be calculated from the weight of the body, with an error varying from 8 to 10 per cent. The weight of the body in pounds is multiplied by the coefficient 1.9 for males of average weight, by 1.8 for females of average weight, by 1.6 for obese males, by 1.5 for obese females and by 2.1 for thin persons. These coefficients have been employed in this study.

It was also shown[20] that the weight of the heart does not increase with age, irrespective of the weight of the body. Previous data emphasizing this relationship are fallacious, probably because of the inclusion of hearts of elderly subjects who had had hypertension.

RESULTS

In this material there were forty-two males and thirty-seven females. The average age of the patients was forty and eight-tenths years, the youngest patient was aged eleven years, and the oldest patient was aged sixty-nine years. Nine children are included in this material, and it must be emphasized here that the standards of cardiac weight of children are uncertain, and that the computations in this study with reference to children are probably associated with a greater error than those pertaining to adults.

TABLE I

CARDIAC HYPERTROPHY GROUPED ACCORDING TO VALVULAR DEFECTS
(SEVENTY-NINE CASES)

VALVULAR LESIONS	CASES	MALES	FEMALES	AVERAGES								
				AGE, YEARS	AGE AT ONSET OF RHEUMATIC FEVER, YEARS	INTERVAL FROM FIRST ATTACK OF RHEUMATIC FEVER TO DEATH, YEARS	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT
Aortic stenosis	9	8	1	48.6	17.4	31.2	686	387	51	72.6	173	0.96
Aortic insufficiency	10	7	3	40.9	17.6	23.3	574	290	47	76.3*	172*	0.82*
Multiple valvular lesions	20	12	8	38.7	18.5	20.2	524	281	50	65.2*	169*	0.86*
Mitral stenosis and insufficiency	35	13	22	39.8	17.9	21.9	469	222	46	62.4*	165*	0.76*
Mitral insufficiency	5	2	3	42.4	21.2	21.2	314	77	25	62.9*	164*	0.52*

*Children excluded in computations.

In order to permit comparative study the cases were grouped as is shown in Table I. Our first analysis concerns the average values derived in the subdivision of the cases into the foregoing groups.

The greatest cardiac weight occurred in the cases in the first group (aortic stenosis) in which the average weight was 686 gm. In order of cardiac weight, the other groups presented the following average values: aortic insufficiency, 574 gm.; multiple valvular lesions, 524 gm.; mitral stenosis and insufficiency, 469 gm.; and pure mitral insufficiency, 314 gm. The heart-weight body-weight ratios were increased 25 to 131 per cent over normal (male and female average normal 0.415 per cent) (Table I).

No definite correlation was evident between cardiac weight on the one hand and, on the other, the interval from the first attack of rheumatic fever to death. However, the longest interval appeared in the cases of aortic stenosis in which occurred the greatest average age at death. The intervals in the other groups were so closely approximated as to be insignificant.

This order of cardiac weights conforms with clinical impressions, and is in agreement with Cabot's figures, which included 1,230 postmortem examinations.

Aortic Stenosis.—There were nine cases of aortic stenosis in which all the requirements for inclusion in this study were present. Eight of the patients were males and one was a female. The average age was forty-eight and six-tenths years; the youngest patient was thirty-one years of age, and the oldest sixty-six years. Death occurred from heart failure in six cases; in all but one case, that of sudden death, the syndrome of congestive heart failure was present. Death occurred as the result of acute bacterial endocarditis *(B. influenzae)* in one case, from pyelonephritis in one, and from pneumonia in another.

It is necessary to emphasize the fact that studies of weight in the presence of congestive heart failure include a variable error, differing considerably with the individual patient and depending on the amount of edema fluid retained. This variable, which obviously cannot be determined, may materially influence the weight of the body. Congestive heart failure occurred in 58 per cent of the entire series of seventy-nine cases.

The data in Table II are arranged according to the degree of aortic stenosis (Grade 0 to 4); Grade 4 indicates almost complete closure of the aortic orifice, whereas Grade 1 denotes slight but actual narrowing in the diameter of the orifice. A definite correlation between the degree of stenosis and the average cardiac weights is evident. The correlation between the average cardiac weights, on the one hand, and, on the other, the average intervals from the first attack of rheumatic fever to death is suggestive but not definite. Only one attack of rheu-

matic fever occurred among the patients of this group. The other data pertaining to body habitus, individual cardiac weights and so forth, are expressed in Table II.

TABLE II

CARDIAC HYPERTROPHY IN PRESENCE OF AORTIC STENOSIS (NINE CASES)

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	STENOSIS, GRADE	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
1	40 M	86.3	188	1.36	Heart failure*	4	1017	656	65	28
2	62 M	72.7	184	1.35	Heart failure*	4	980	676	69	49
Averages	51	79.5	186	1.35			999	666	67	39
3	51 M	77.2	171	0.99	Heart failure*	3	770	447	58	38
4	50 M	58.6	154	1.12	Acute bacterial endocarditis	3	760	515	68	44
5	48 M	81.8	173	0.87	Heart failure*	3	717	369	51	20
6	31 F	59.0	162	0.97	Heart failure	3	573	339	59	18
Averages	45	69.2	165	0.99			705	423	59	30
7	40 M	70.4	172	0.97	Heart failure*	2	685	390	57	10
8	66 M	78.1	172	0.48	Pyelonephritis	2	356	46	13	36
Averages	53	74.2	172	0.73			521	218	35	23
9	50 M	65.0	183	0.49	Pneumonia	1	320	49	15	38

*Congestive heart failure.

Holman and Beck produced experimental aortic stenosis in dogs by constricting the aorta with tape. Three such experiments are reported, but unfortunately the terminal cardiac weight of only one animal is mentioned. The dog weighed 20 kg.; and after the lapse of six months the heart weighed 165 gm. and the heart-weight body-weight ratio was 1.21 per cent. The normal ratio for dogs is recorded as 0.72 per cent by Joseph and 0.798 per cent by Herrmann, an average of 0.76 per cent. This represents an increase in 37 per cent over the normal average heart-weight body-weight ratio. The aorta was constricted to half its normal diameter.

Eyster, Meek and Hodges produced experimental aortic stenosis in nineteen dogs, and studied the size of the heart by serial roentgenographic silhouettes, but failed to record terminal cardiac weights. The average increase in silhouette for the entire series was 10.5 per cent of the original area. The initial increase in shadow is interpreted by these workers to indicate dilatation from which the heart may entirely or partially recover, whereas subsequent enlargement, developing slowly, probably indicates hypertrophy.

Aortic Insufficiency.—This group comprised ten cases in which seven were males and three females. The average age was forty and nine-tenths years, seven and seven-tenths years less than that of patients

TABLE III

CARDIAC HYPERTROPHY IN PRESENCE OF AORTIC INSUFFICIENCY (TEN CASES)

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	INSUFFICIENCY, GRADE	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
1	30 M	81.8	175	1.16	Heart failure*	3	950	608	64	10
2	62 M	80.9	171	1.11	Heart failure*	3	900	562	62	29
3	30 M	113.6	172	0.72	Heart failure*†	3	826	426	52	13
Averages	41	92.1	173	1.00			892	532	59	17
4	21 F	50.9	165	1.21	Pneumonia	2	615	413	67	21
5	58 F	83.1	166	0.66	Strangulated hernia†	2	550	257	46	28
6	67 M	90.9	186	0.49	Intestinal hemorrhage	2	444	64	14	51
Averages	49	74.9	172	0.79			536	245	42	33
7	12 F	40.9	147	0.92	Heart failure*	1	376	214	57	7
8	13 M	33.8	150	1.00	Heart failure*	1	340	195	57	1
9	37 M	59.0	168	0.57	Subacute bacterial endocarditis	1	338	91	27	28
10	63 M	50.0	169	0.60	Inanition‡	1	300	69	23	45
Averages	31	55.0§	159§	0.77§			339	142	41	20

* Congestive heart failure.

† Obesity.

‡ Emaciation.

§ Children excluded in body weight and height averages.

with aortic stenosis. The youngest patient was twelve years of age and the oldest was sixty-seven years of age. Five patients died of congestive heart failure, one patient died of subacute bacterial endocarditis *(Streptococcus viridans)*; whereas the remainder of the patients died from diseases unrelated to the heart (Table III).

Two patients were obese and one was emaciated, which facts were considered in the calculation of the increased weight of the heart over the normal for the given person.

The data in Table III are arranged according to the degree of aortic insufficiency (Grade 0 to 4). Again, a clear-cut correlation between the degree of lesion and the average weight of the hearts occurred. No correlation appeared between weights of the hearts, on the one hand, and, on the other, the individual and average intervals from the first episode of rheumatic fever to death. Only one attack of rheumatic fever occurred among these patients. Detailed data dealing with cardiac weight and body habitus may be noted in Table III.

We wish to call attention to Case 8 (Table III) of this group. The patient was a boy, aged thirteen years, who died of congestive heart failure one year following his first attack of rheumatic fever. The heart weighed 57 per cent more than the calculated normal cardiac weight for this boy's habitus. This case and three similar cases of patients who survived for a short time following rheumatic fever with marked cardiac hypertrophy are reported in the succeeding groups and will be considered more fully later in this paper.

It is of interest to compare these data to similar data dealing with experimental aortic insufficiency of dogs. Bazett and Sands, in their experiments on dogs, demonstrated cardiac hypertrophy, particularly of the left ventricle. They reported the results of nine experiments, the dogs surviving from two days to ten months. The heart-weight body-weight ratios of six dogs were definitely greater than the stated normal values.[11, 14] They ranged from 0.81 to 0.91 per cent; the average was 0.87 per cent. This is greater than the average (0.82 per cent) found in our cases. The terminal weights of the dogs' hearts ranged from 91 to 177 gm.

The experimental data on aortic insufficiency were also brought out in studies by Eyster, Meek and Hodges.

Multiple Valvular Lesions.—Twenty patients had multiple valvular lesions, and the details regarding the type of lesion and the valves involved may be noted in Table IV. There were twelve males and eight females. The average age of the group was thirty-eight and seven-tenths years; the youngest patient was aged eleven years, and the oldest sixty-nine years. Twelve patients died of congestive heart failure, three of subacute bacterial endocarditis *(Streptococcus viridans)*, one of coronary embolism, and the remainder from causes unrelated to the heart.

As in the previous groups, a definite correlation between the degree of lesion and the average cardiac weight occurred. Because the lesions were multiple and varied in this group, the predominant defect is considered primarily. A correlation between the average weights of the hearts, on the one hand, and, on the other, the interval from the first attack of rheumatic fever to death in these cases was evident. However, in view of the findings in the other groups, this relationship may be casual. Two patients were emaciated and one was obese, and the proper coefficients were utilized in the computations of cardiac weight.

It is interesting that multiple lesions apparently do not exert as great a mechanical effect as certain isolated lesions.

Mitral Stenosis and Insufficiency.—This group included thirty-five patients. There were thirteen males and twenty-two females. The average age for the group was thirty-nine and eight-tenths years; the youngest patient was aged eleven years, and the oldest sixty-five years. Twenty-three patients had died of congestive heart failure, five of subacute bacterial endocarditis *(Streptococcus viridans)*, and the remainder from causes unrelated to the heart.

A correlation between the severity of the lesion and the average cardiac weights is again evident if the case in which the lesion was graded 4 is excluded. As this grade is represented by only one case, it is reasonable to presume that a greater number of cases would bring the average cardiac weight above that in Grade 3. The stenotic element predominated over that of insufficiency in all cases, and therefore formed the basis for grading.

Five patients in this group were the only persons in the entire series to suffer more than one attack of rheumatic fever. Four patients had two attacks; one patient had six attacks. One patient was obese, and proper recognition of this fact was made in our computations (Table V).

Mitral Insufficiency.—There were only five cases (6 per cent) of pure mitral insufficiency. It is a recognized fact that pure mitral insufficiency without stenosis is rare, and we believe that our cases thus tabulated are bona fide examples of this lesion. In these cases there were two males and three females. The average age was forty-two and four-tenths years; the youngest patient was aged thirteen years, and the oldest sixty-one years. It is interesting and significant to note that only one patient died of heart disease (Table VI).

A correlation between the degree of lesion and the average weight of the heart likewise appears to prevail in this small group of cases. No correlation between the cardiac weight, on the one hand, and, on the other, the interval from the first attack of rheumatic fever to death is evident in the individual cases, although the averages appear to show a trend.

TABLE IV

CARDIAC HYPERTROPHY IN PRESENCE OF MULTIPLE VALVULAR LESIONS (TWENTY CASES)

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	DOMINANT VALVULAR LESION, GRADE	TYPES AND GRADES OF VALVULAR LESIONS	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
1	46 M	68.1	174	0.96	Heart failure*	4	Mitral stenosis 4, aortic insufficiency 2, and stenosis	658	373	57	36
2	58 M	70.0	172	1.37	Heart failure*	3	Aortic stenosis 3, mitral stenosis 2	960	667	68	44
3	35 M	70.6	179	1.13	Subacute bacterial endocarditis	3	Aortic insufficiency 3, mitral stenosis 2	800	504	63	28
4	53 M	72.7	170	1.01	Heart failure*	3	Aortic stenosis 3, mitral stenosis 2, mitral insufficiency 2	738	434	59	21
5	34 M	59.0	172	1.06	Heart failure*	3	Mitral stenosis 3, aortic stenosis 2, tricuspid stenosis 2	630	383	61	13
6	13 F	31.1	154	2.24	Heart failure*	3	Aortic insufficiency 3, mitral stenosis 1	595	472	79	1.5
7	43 M	65.0	165	0.85	Heart failure*	3	Aortic stenosis 3, mitral stenosis 2	552	280	51	15
8	68 M	59.0	177	0.91	Heart failure*	3	Aortic stenosis 3, mitral stenosis 3, mitral insufficiency 1	542	295	54	54
9	47 M	75.0	168	0.70	Peritonitis	3	Mitral stenosis 3, aortic insufficiency 3	525	211	40	10
10	12 F	36.1	149	1.42	Heart failure*	3	Mitral stenosis 3, aortic insufficiency 1	517	374	72	4
11	36 F	47.2	157	0.96	Coronary embolism	3	Mitral stenosis 3, aortic stenosis 2	452	265	59	6
12	37 M	75.0	165	0.56	General paresis	3	Mitral stenosis 3, tricuspid stenosis 2	423	110	26	12
Averages	40	65.9†	169†	1.11†				612	363	57	19

TABLE IV—CONT'D

CASE	AGE, YEARS AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	DOMINANT VALVULAR LESION, GRADE	TYPES AND GRADES OF VALVULAR LESIONS	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
13	57 F	63.6	150	0.86	Heart failure*	2	Mitral stenosis 2, aortic insufficiency 2	547	295	54	15
14	69 M	58.6	177	0.80	Heart failure	2	Aortic stenosis 2, mitral stenosis 1, mitral insufficiency 2	471	226	48	49
15	17 M	49.5	170	0.87	Subacute bacterial endocarditis‡	2	Mitral stenosis 2, mitral insufficiency 1, aortic insufficiency 2	435	206	47	2
16	44 F	86.8	166	0.49	Heart failure§	2	Mitral stenosis 2, aortic insufficiency 2	433	32	7	24
17	50 F	63.6	174	0.64	Poisoning	2	Mitral stenosis 2, aortic insufficiency 1	407	155	38	8
18	31 F	59 5	165	0.63	Subacute bacterial endocarditis	2	Mitral stenosis 2, aortic insufficiency 1	380	144	38	24
19	13 M	50.0	137	0.60	Heart failure*	2	Mitral insufficiency 2, aortic stenosis 1	300	91	30	13
20	11 F	27.2	142	0.80	Chorea‡	2	Aortic insufficiency 2, mitral insufficiency 2	220	94	43	1 mo.
Averages	37	63.6†	167†	0.71†				399	155	38	17

*Congestive heart failure.
†Children excluded in body weight and height averages.
‡Emaciation.
§Obesity.

TABLE V

CARDIAC HYPERTROPHY IN PRESENCE OF MITRAL STENOSIS AND INSUFFICIENCY (THIRTY-FIVE CASES)

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	STENOSIS, GRADE	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
1	43 M	63.6	171	0.62	Heart failure*	4	413	147	36	28
2	52 F	60.9	158	1.20	Heart failure*	3	730	489	67	43
3	33 M	65.9	181	1.07	Heart failure*	3	707	431	61	16
4	48 F	45.9	165	1.45	Heart failure*	3	665	483	73	26
5	21 M	75.0	175	0.86	Heart failure*	3	644	330	51	8
6	65 M	84.0	171	0.75	Heart failure*	3	630	278	44	50
7	44 M	58.6	177	1.04	Heart failure*	3	610	365	60	4
8	38 M	58.1	179	0.99	Heart failure*	3	585	342	58	26
9	53 F	54.5	156	1 02	Heart failure*	3	557	341	61	41
10	45 F	59.0	165	0.93	Heart failure*	3	548	314	57	21
11	21 M	56.8	179	0.90	Subacute bacterial endocarditis	3	514	276	54	7
12	45 F	90.9	172	0.53	Heart failure*†	3	489	169	35	16
13	36 F	75.0	165	0.62	Heart failure*	3	465	168	36	15
14	43 F	51.8	163	0.89	Heart failure*	3	465	260	56	33
15	34 M	54.5	165	0.78	Heart failure*	3	429	201	47	9
16	48 F	46.8	159	0.90	Cerebral embolism	3	425	240	56	36
17	40 F	54.5	166	0.75	Heart failure*	3	410	194	47	14
18	37 F	54.0	162	0.62	Heart failure*	3	340	126	37	27
Averages	41	61.5	166	0.90			542	294	53	23

* Congestive heart failure.

† Obesity.

‡ Children excluded in body weight and height averages.

TABLE V—CONT'D

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	STENOSIS, GRADE	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
19	50 M	95.4	174	0.77	Uremia	2	712	313	44	29
20	16 F	47.7	165	1.05	Subacute bacterial endocarditis	2	505	316	62	11
21	40 M	84.0	169	0.57	Subacute bacterial endocarditis	2	485	133	27	22
22	37 M	79.5	173	0.59	Heart failure*	2	470	137	29	4
23	37 F	48.1	164	0.93	Heart failure*	2	450	259	58	29
24	55 F	81.8	171	0.54	Brain tumor	2	444	120	27	37
25	23 F	44.5	157	0.91	Subacute bacterial endocarditis	2	405	229	57	13
26	61 F	79.5	172	0.50	Diabetic gangrene	2	397	82	21	31
27	23 F	45.4	160	0.90	Subacute bacterial endocarditis	2	390	210	54	10
28	40 M	56.8	178	0.61	Heart failure*	2	350	112	32	19
29	53 F	68.1	165	0.51	Heart failure*	2	349	79	23	42
30	23 F	61.3	163	0.55	Heart failure*	2	337	94	28	12
31	42 F	45.4	162	0.70	Pneumonia	2	320	140	44	24
32	48 F	60.4	158	0.52	Exophthalmic goiter	2	315	76	24	32
33	29 F	45.2	155	0.66	Heart failure*	2	300	105	35	17
34	11 M	32.7	140	0.90	Heart failure*	2	294	157	53	6
Averages	37	63.6‡	170‡	0.70‡			408	160	40	21
35	62 F	54.5	158	0.52	Carcinoma of common bile duct	1	283	67	24	9

TABLE VI

CARDIAC HYPERTROPHY IN PRESENCE OF MITRAL INSUFFICIENCY (FIVE CASES)

CASE	AGE, YEARS, AND SEX	BODY WEIGHT, KG.	HEIGHT, CM.	RATIO OF HEART WEIGHT TO BODY WEIGHT	CAUSE OF DEATH	INSUFFICIENCY, GRADE	ACTUAL HEART WEIGHT, GM.	INCREASE IN HEART WEIGHT OVER CALCULATED NORMAL, GM.	PERCENTAGE INCREASE OVER CALCULATED NORMAL	INTERVAL FROM RHEUMATIC FEVER TO DEATH, YEARS
1	28 M	78.6	167	0.54	Pneumonia	2	396	67	17	20
2	60 F	73.6	155	0.47	Carcinoma of rectum	2	351	59	17	26
3	61 F	54.5	160	0.54	Cachexia of carcinoma	2	297	81	27	49
4	13* F	36.3	149	0.81	Heart failure*	2	295	151	51	4 months
Averages	41	68.9†	161†	0.59†			335	90	28	24
5	50 M	45.0	175	0.51	Ulcerative colitis‡	1	232	25	11	12

* Congestive heart failure.
† Children excluded in body weight and height averages.
‡Emaciation.

COMMENT

In a recent investigation, Levine and Carr divided and weighed a series of hearts of human beings according to the experimental method of Herrmann.[10] Fractional weights were determined in fifteen cases of rheumatic heart disease, including five cases of mitral stenosis and insufficiency, three cases of aortic stenosis and insufficiency, five cases of mitral and aortic stenosis and insufficiency, one case of mitral, aortic, and tricuspid stenosis and insufficiency, and one case of thrombo-endocarditis of the mitral valve. The conclusions pertinent to this study are that in rheumatic defects of the mitral valve alone the increase in cardiac weight is the result of an increase in the weight of the right ventricle and the auricles. In large hearts associated with aortic insufficiency, rheumatic or syphilitic, hypertrophy of the whole heart occurs, but the greatest increase is in the left ventricle. Levine and Carr expressed the belief that mechanical factors are not entirely responsible for the production of cardiac hypertrophy.

We shall attempt to apply the analysis of our data to the various hypotheses advanced regarding the production of cardiac hypertrophy.

The hypothesis that increased cardiac work causes hypertrophy finds unmistakable confirmation in this study, as almost without exception the average weight of the hearts paralleled the degree of valvular deformity. The work demanded of the heart appears to be primarily concerned with the magnitude of the mechanical barrier. In considering increased work, however, the interval of time during which the heart is subjected to increased work cannot be disregarded; and although it undoubtedly plays an important part in many cases, the mechanical factor may exert its influence overwhelmingly, so that the time element apparently becomes submerged.

Our study does not deal with the coronary circulation, so that we do not have data regarding coronary blood flow and cardiac hypertrophy. We know of no proof to the effect that an increase in muscle mass provokes an increase in coronary blood flow, thus furthering cardiac hypertrophy. In fact, the opposite conclusion is not improbable, that in greatly hypertrophied hearts the normal coronary circulation becomes relatively insufficient, since its work may be doubled or even trebled, as the case may be.

The question of the relationship of inflammatory lesions of the myocardium to cardiac hypertrophy is one of considerable interest. In this connection it is important to consider the cases of the four children briefly mentioned earlier in this paper who survived for short periods following their first rheumatic infection.

REPORT OF CASES

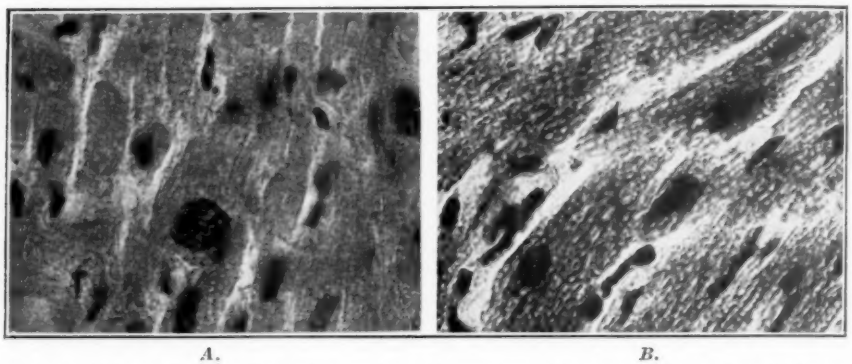
CASE 1.—(Case 8, Table III.) A boy, aged thirteen years, died of congestive heart failure one year following his first attack of rheumatic fever. Only a slight degree of aortic insufficiency (Grade 1) was found at necropsy, but the heart weighed

340 gm., an increase of 195 gm. (57 per cent) over the calculated normal. Neither the degree of the mechanical lesion nor the duration of the lesion seemed capable of producing cardiac hypertrophy of this magnitude. This boy had had only one attack of rheumatic fever.

CASE 2.—(Case 6, Table IV.) A girl, aged thirteen years, died of congestive heart failure one and a half years following the first episode of rheumatic fever. Multiple lesions were present; namely, aortic insufficiency Grade 3, and mitral stenosis Grade 1. Marked hypertrophy was found, the heart weighing 595 gm., an increase of 472 gm. (79 per cent) over the calculated normal.

CASE 3.—(Case 4, Table VI.) A girl, aged thirteen years, survived only four months after the initial and only attack of rheumatic fever and died of congestive heart failure. The only valvular defect demonstrable was mitral insufficiency Grade 2; yet the heart weighed 295 gm., an increase of 151 gm. (51 per cent) over the calculated normal.

CASE 4.—(Case 20, Table IV.) A girl, aged eleven years, was of unusual interest owing to the extremely brief survival period. She died one month after the onset of



A. *B.*

Fig. 1.—*A*, Section of normal heart muscle; *B*, section of heart muscle in Case 3 (Case 4, Table VI), marked vacuolar degeneration.

chorea. The valvular lesions demonstrated after death consisted of aortic and mitral insufficiency Grade 2. The heart weighed 220 gm., an increase of 94 gm. (43 per cent) over the calculated normal.

One of us repeatedly observed these children, and we are certain that no preexisting cardiac lesion was responsible for the cardiac hypertrophy. The cardiac injury without question occurred with the infections as stated.

Careful microscopic study of numerous sections of heart muscle of these four subjects revealed unusually marked evidences of myocarditis (Figs. 1, 2 and 3). There were extensive areas of cellular infiltration, the cells consisting chiefly of polymorphonuclear leucocytes and small lymphocytes, and certain areas revealed numerous erythrocytes. Considerable fibrin was deposited in these regions. Considerable swelling of the muscle fibers was apparent, and their striations were indistinct. There were numerous collections of cells scattered throughout the

myocardium resembling Aschoff cells. The changes described were most prominent in Cases 1 and 2, although they were well marked in the other two cases.

It appears that the marked myocarditis of these children was the chief factor contributing to the production of the cardiac hypertrophy, in view of the fact that the degree of endocarditis present and its resulting valvular deformity were considerably less than that occurring in the majority of cases. Stewart's experimental work indicated a relationship between myocarditis and cardiac hypertrophy. He produced extensive myocarditis in rabbits by intravenous injection of epinephrine, and found ensuing hypertrophy of considerable degree. The exact manner in which myocarditis produces hypertrophy is not clearly understood, but it is not improbable that it may represent a

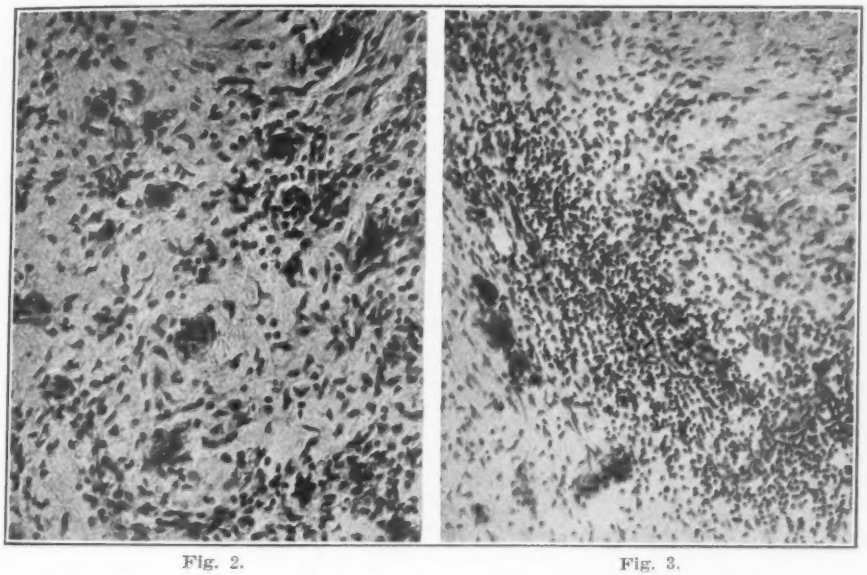


Fig. 2. Fig. 3.

Fig. 2.—Section of heart muscle from Case 4, showing Aschoff cells.

Fig. 3.—Section of heart muscle from Case 4, showing areas of marked cellular infiltration.

compensatory effort on the part of regions of normal or relatively normal muscle. These findings strongly suggest that in some cases of severe infection the myocardium responds to the injury of hypertrophy.

Our investigation resulted in no data concerning the influence of increase in the midsystolic period on cardiac hypertrophy, nor on the influence of residual blood in the ventricle.

We concur with Herrmann in his belief that a combination of influences participates in the production of cardiac hypertrophy.

CONCLUSIONS

1. The greatest average cardiac weight occurred in cases of aortic stenosis. In order of cardiac weight other lesions occurred in the

following sequence: aortic insufficiency, multiple valvular lesions, mitral stenosis and insufficiency, and pure mitral insufficiency.

2. There was an outstanding correlation between the degree of the lesion and the average weight of the heart.

3. There was a suggestive correlation, evidenced only in some groups, between the average weight of the heart, on the one hand, and, on the other, the interval elapsing from the initial attack of rheumatic fever to death.

4. The condition of four children, who lived only for a very short time following their first illness with rheumatic fever, and chorea in one case, and three of whom had rather slight valvular defects, strongly suggests that myocardial injury by infection or its toxins in some instances permits the heart to respond by hypertrophy.

5. Although increased cardiac work imposed by the valvular defect or defects appears to be the outstanding influence in the production of cardiac hypertrophy in rheumatic heart disease, other factors appear to exert a definite but less important influence. Among them is the length of time that the heart is subjected to the lesion and actual myocardial injury in a certain group of cases.

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THE PULMONARY AND PLEURAL COMPLICATIONS OF AORTIC ANEURYSM*

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ONE of the ways in which an aneurysm of the aorta may masquerade is in the form of a chronic pulmonary or pleural infection. This is especially true of aneurysms of the descending part of the arch of the aorta and is commonly the result of compression of the trachea or bronchi with its complications. Other causes are obstruction of the pulmonary veins, direct invasion of the lung, hemorrhage into the pleural cavity, bronchoesophageal fistula, or an intercurrent tuberculosis of the pleura or lungs.

In view of the fact that these pleural and pulmonary complications may completely dominate the clinical picture, we have reviewed and analyzed the clinical and pathological features of 22 cases of aneurysm of the aorta in which the main symptoms and signs were referable to the lungs or pleura. We present here the results of this study. The cases are briefly summarized in Tables I and II.

COMMENT

General Features.—Of the 22 cases summarized in Table I, only 2 occurred in women. The patients' ages varied from twenty-eight to seventy-one years, the majority being between thirty and sixty years old. The symptoms referable to the chest varied in accordance with the position of the aneurysm and the mechanical embarrassment produced by the mass. Thus, pain, cough and expectoration, dyspnea and hemoptysis were the common symptoms. Data concerning the character of the lesions together with the type of complications produced in the lungs and bronchi are summarized in Table II. Compression of the trachea or of the bronchi, more often the left, were the commonest complications; and bronchopneumonia, lung abscesses, and bronchiectasis were the most frequent results of these lesions. The signs, therefore, depended upon the type of complication, and are discussed in more detail below. Once infection was present, fever and leucocytosis were the rule, the temperature was irregular, varying between 100° and 105° F.; the white blood cells between 6,800 and 68,000 per cubic millimeter. The duration of the pulmonary symp-

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toms and signs varied from ten days to as long as three years; in most cases, however, from a few weeks to a few months.

From the cases summarized in Table I, and others reported in the literature,[1-10] it is evident that a variety of pulmonary and pleural lesions may result indirectly from an aneurysm of the aorta. Indeed, as we have stated, these complications may be so prominent that they completely dominate the clinical picture. Of the 4,000 cases of aortic aneurysm collected by Boyd[11] the incorrect diagnoses that had been made in 130 were summarized. In about half of these cases the diagnosis was some form of pulmonary or pleural infection. Among the conditions mentioned were tuberculosis, asthma, chronic bronchitis, pleural effusion, pleural empyema, pericarditis, pleurisy, and abscess of the lung. As a matter of fact, in the cases observed by us all of these conditions occurred and, in addition, hemothorax, bronchiectasis, atelectasis, and rupture of the aneurysm into the lung. The diagnosis of aneurysm may be difficult in the presence of one of the above mentioned complications, but should be entertained in any case of obscure pulmonary or pleural infection. These various complications will be discussed in some detail.

Tracheal Compression.—This usually results from pressure on the trachea by an aneurysm of the innominate artery or of the transverse arch of the aorta. Of the cases recorded in Table I there were five cases of aneurysm of the transverse arch and two cases of aneurysm of the innominate artery causing tracheal compression. The symptoms and signs were cough, dyspnea, stridor, chronic tracheobronchitis, with signs of emphysema and bilateral bronchopneumonia. One may observe: (1) attacks of acute bronchitis with bronchopneumonia and temporary recovery; (2) chronic bronchitis followed by bronchopneumonia and death; (3) chronic bronchitis with recurrent bouts of fever, gradual failure, bronchiectasis, and death; (4) gradual suffocation due to retention of tracheal and bronchial secretions; (5) rupture of aneurysm into the trachea. An aneurysm in this location is not difficult to detect clinically and should give rise to no diagnostic difficulties. Case 4 illustrates the course of events when the trachea is compressed.

It was of considerable interest that tracheal compression was accompanied by bilateral anatomical lesions and physical signs, such as emphysema, chronic bronchitis, and bronchopneumonia. This was in striking contrast to the cases in which a main bronchus was compressed. The following case illustrates the course of events when the trachea was compressed:

CASE 4.—*A man with an aneurysm of innominate artery has symptoms and signs of tracheal compression with bilateral bronchopneumonia. Death due to rupture into trachea.*

TABLE

SUMMARY OF TWENTY-ONE CASES OF AORTIC ANEURYSM

CASE NO.	AGE SEX	SYMPTOMS	SIGNS	DURATION OF PULMONARY SIGNS
				Tracheal
1	55 ♂	Cough—6 mo. Dyspnea—6 mo.	Aortic insufficiency. Compression of right main bronchus. Tracheal compression. Bilateral bronchopneumonia.	6 months.
2	37 ♂	Cough—3 yr. Expectoration—1 mo.	Tracheal compression. Râles both lungs with bronchopneumonia.	3 years. Acute—1 month.
3	49 ♂	Cough and expectoration—9 wk. Dyspnea—3 wk.	Tracheal compression. Bilateral bronchitis.	6-9 weeks.
4	57 ♂	Cough—3 wk. Expectoration—2 wk. Dyspnea—5 wk.	Tracheal obstruction. Bilateral bronchopneumonia.	5 weeks.
5	60 ♂	Cough—4 mo. Expectoration.	Emphysema and chronic bronchitis. Aneurysm of transverse arch.	4 weeks when first seen.
6	46 ♂	Pain in back. Shortness of breath.	Bilateral bronchopneumonia.	Pain in left shoulder and back of neck, shortness of breath—14 mo. Choking in throat, dysphagia—2 wk. Cough—10 days. Hemoptysis—4 days. Purulent bronchitis.
7	39 ♂	Difficulty in breathing. Cough.	Tracheal obstruction. Right radicle less than left. W. R.+ Bilateral bronchopneumonia. Neck seems distended.	2 months. Difficulty in breathing.
				Bronchial
8	42 ♂	Pain—2 mo. Dyspnea—7 mo. Cough and expectoration—9 mo. Loss of weight—6 mo. Dysphagia—3 mo.	Solidification of right upper lobe. Bronchopneumonia right lung. Pulsus differans.	9 months.
9	65 ♂	Cough, expectoration, loss of weight.	Limited expansion. Dullness left tip. Râles faint left axilla.	Weakness, cough—8 wk. duration. Mucopurulent sputum.
10	38 ♂	Cough and expectoration—3 wk. Pain in chest—5 days.	Aortic insufficiency. Bronchial obstruction left side. Bronchopneumonia left lower lobe.	3 weeks.

I

WITH PULMONARY AND PLEURAL COMPLICATIONS

TEMPERATURE	WHITE BLOOD CELLS THOUSANDS PER C.MM.	PATHOLOGICAL CHANGES	REMARKS
Compression			
97°-103°	14.0	Aneurysm compressing right bronchus and trachea. Acute bronchitis and bronchopneumonia. Fibrinopurulent pericarditis.	
101°-103°	16.0	Autopsy not done.	Purulent sputum.
97°-99.5°	10.3	Aneurysm compressing and eroding the trachea.	
100°-102°	14.5	Aneurysm of innominate artery. Tracheal compression. Chronic bronchitis. Rupture into trachea.	
98°-101°	34.5	Recovered.	
98°-102°	6.1	Aneurysm of transverse aortic arch. Purulent bronchitis. Compression of trachea with opening.	
99°-101.5°	15.5	Aneurysm of innominate with obliteration of right subclavian artery. Erosion of trachea with compression. Bronchopneumonia — both lower lobes.	
Compression			
99°-104°	6.0-18.0	Compression of right bronchus. Abscess and bronchiectasis of right lung. Narrowing of orifice of innominate artery.	Patient had been admitted to sanatorium for tuberculosis. 50 to 100 c.c. sputum daily.
98°-101°	12.2	Aneurysm with pressure erosion of spine and left main bronchus. Bronchopneumonia. Slight bilateral hydrothorax.	
99°-102°	9.0-11.3	Hydrothorax, right-sided. Compression of left bronchus. Bronchopneumonia left lung.	Patient had a similar attack of pulmonary disease one year before death.

TABLE

CASE NO.	AGE SEX	SYMPTOMS	SIGNS	DURATION OF PULMONARY SIGNS
11	56 ♂	Cough—1 mo. Cough and expectoration —3 wk. Fever—5 days. Dyspnea.	Compression left main bronchus.	1 month.
12	28 ♀	Dyspnea, cough and pain in chest.	Signs of fluid at left base. Coughed up blood and died.	10 weeks.
13	30 ♂	Pain—2 yr.	Stridor. Bronchial compression left bronchus. Bronchopneumonia left lung.	2 weeks—recovery.
14	45 ♂	Dyspnea—2 yr. Cough and expectoration —6 mo. Loss of weight. Pain.	Pneumonia left lower lobe. Compression of left upper lobe.	6 months.
15	71 ♀	Pain—5 yr. Dyspnea—2 yr.	Compression of left main bronchus.	2 years.
				Invasion of
16	38 ♂	Pain in right chest—10 days.	Signs of right pleural effusion.	7 weeks.
17	58 ♂	Pain in chest—2 yr. duration.	Dullness over left upper lobe.	5 days.
18	65 ♂	Pain—1 yr. Repeated hemoptyses—9 mo.	Dullness and râles over left upper lobe.	9 months.
				Tuber
19	52 ♂	Pain. Dyspnea.	Pleural effusion left side. Pulsus differans.	6 months.
20	45 ♂	Pain in chest and back. Cough—4 wk. Tbc. right upper lobe.	Signs of tbc. of right upper lobe.	4 weeks. Aneurysm ruptured into right lung.
21	51 ♂	Weakness, dyspnea and swelling of legs—3 wk. Bronchitis—4 yr.	Bilateral bronchopneumonia.	Signs of bronchopneumonia with failure —3 weeks.

I—CONT'D

TEMPERATURE	WHITE BLOOD CELLS THOUSANDS PER C.MM.	PATHOLOGICAL CHANGES	REMARKS
99°-101°	14.8	Aneurysm compressing trachea, left bronchus, left lung.	Organizing pneumonia left lower lobe. Had acute attack one month before.
98.6°	10.6	Aneurysm of descending aorta. Rupture into left bronchus. Atelectasis of left lung with pleural effusion left. Emphysema right lung. Right cavity obliterated by fibrous adhesions.	
102°-105°	10.2		Recovered from an acute attack of pneumonia. Wassermann reaction negative. X-ray signs of aneurysm.
100°-104°	18.0-27.0	Aneurysm of descending arch. Compression of left main bronchus. Bronchiectasis of left lower lobe. Compression of left upper lobe.	Mass did not pulsate on fluoroscopic examination.
98°-99°	6.0	Aneurysm of arch of aorta compressing left main bronchus. Atelectasis of left lower lobe. Rupture into bronchus.	
Pleura or Lung			
99°-101°	28.2	Aneurysm of descending aorta. Rupture into right pleural and pericardial cavity.	
99°-101°	15.0-21.0	Aneurysm of descending arch of aorta. Rupture into left lung and pleural cavity.	
98.6°-100°	6.0	Aneurysm invading left lung. Rupture into lung.	Anemia developed from loss of blood. Hgb. 50 per cent.
culosis			
99°-103°	6.0	Tuberculosis of pleura resulting from Pott's disease. Aneurysm of descending arch of aorta.	
101°	Not given	Rupture of sacular aneurysm of the transverse arch of aorta with extension post into bodies of the vertebrae and left lung. Pulmonary tbc.	
99°-101°	12.95	Aneurysm of transverse arch of aorta. General pulmonary tbc. with cavitation.	Diffuse tbc. No clinical signs of aneurysm. Cardiac insufficiency.

A man, fifty-seven years of age, complained of cough and inability to breathe comfortably of five weeks' duration. Three weeks before entering the hospital he began to have frequent attacks of coughing with profuse expectoration. Shortness of breath persisted, and there was some dull aching pain beneath the sternum. Upon examination he was dyspneic, with stridor and signs of emphysema with diffuse fine râles over both lungs. The breath sounds were distant and somewhat obscured by the râles. The cough was "brassy." There was definite pulsation in the episternal notch and in the infra- and supraclavicular fossae. There was a definite tracheal tug, and the right radial pulse was of larger volume than the left. The white blood count was 14,000 per cubic millimeter and there was no fever. Following a bout of coughing he spat up a large quantity of blood and rapidly died. The clinical diagnoses were: aneurysm of the innominate artery, compression of the trachea, tracheobronchitis, rupture of aneurysm into trachea. This was confirmed by necropsy.

This case illustrates that tracheal compression may result from an aneurysm of the innominate artery. Compression of the trachea is more common, of course, from an aneurysm of the transverse arch of the aorta.

TABLE II

SUMMARY OF PULMONARY AND PLEURAL COMPLICATIONS IN TWENTY-ONE CASES OF ANEURYSM OF THE AORTA

ANATOMICAL LESIONS		NUMBER OF CASES
Tracheal Compression		7
Bilateral bronchitis	4	
Bilateral bronchopneumonia	3	
Bronchial Compression		8
Left Main Bronchus	7	
Bronchiectasis left lower lobe	1	
Bronchopneumonia left lung	3	
Hydrothorax	2	
Organizing pneumonia left lower lobe	1	
Collapse of left lower lobe	2	
Right Main Bronchus	1	
Abscess and bronchiectasis of right upper lobe	1	
Direct Invasion of Lung or Rupture Into Pleura		3
Rupture into pleura	2	
Direct invasion of lung	1	
Pulmonary and Pleural Tuberculosis	3	

Bronchial Compression.—There were eight cases (8-15) in which one of the main bronchi was compressed. In seven the left bronchus was involved, and in the other the right bronchus. In most cases of bronchial compression the aneurysm arises from the descending arch of the aorta. This was not difficult to understand when one appreciates that one of the commonest sites for aneurysms to occur is at the point where the aorta passes over and above the left main bronchus. The symptoms produced by bronchial compression were cough, expectoration, stridor, dyspnea, and attacks of suffocation. At first, when the obstruction was incomplete, there was emphysema of the left lung. Later, when secretions were retained distal to the ob-

struction, there appeared varying degrees of collapse of the lung with or without pneumonia, acute or organized, abscess or bronchiectasis. Once the infection became established, the patients had symptoms of a suppurative pulmonary lesion with fever, loss of weight, sweating, and other constitutional symptoms accompanying a chronic infection. Under these circumstances a diagnosis of tuberculosis may be made, and since both conditions may coexist, one must exclude tuberculosis before being completely satisfied with the diagnosis of "aneurysmal phthisis."

In every case in this group the pulmonary complications were on the same side as the bronchial compression. Moreover, they were more severe, as far as the local pulmonary process was concerned, than when there was tracheal obstruction. In other words, unilateral obstruction may be more complete and produce more extensive pulmonary lesions without rapid death than when there are pulmonary complications resulting from tracheal compression. On occasions, intrinsic tracheobronchial stenosis due to syphilis may cause collapse of the lobe of the lung. This may be associated with an aneurysm, as in a recent case reported by Mallory,[12] or it may be an isolated lesion, the latter being more common. Cases 15 and 14 illustrate the course of events following bronchial compression in patients with an aneurysm of the descending arch of the aorta.

CASE 15.—*An elderly woman with an aneurysm of the descending arch of the aorta shows recurrent collapse of the left lung due to compression of left main bronchus; obliterative endarteritis syphilitica of left common carotid artery and partial occlusion of the innominate and left subclavian artery. Death follows rupture of aneurysm into left main bronchus.*

A white woman seventy-one years of age was first seen two years before death on account of pain over the precordium. She stated that for five years she had suffered from periodic attacks of pain over the precordium and upper part of the left chest. The pain continued with rest and was not increased by exertion; it was worse when she lay on the left side. Examination at that time revealed a small woman with increased retromanubrial dullness, dullness and distant breath sounds over the left lower lung lobe. She left the hospital after several days.

Shortly after leaving the hospital she had an attack of pneumonia from which she recovered completely. Nine months before death she was readmitted to the clinic on account of pain in the chest, cough, and some shortness of breath. Upon examination it was found that she was thin and frail and had lost some weight. The positive findings were a displacement of the trachea to the left, the signs of atelectasis of the lower lobe of the left lung, and inequality of the brachial pulses, the right being less than the left. No pulsation was felt in the left carotid artery and only slight pulsation in the right. There was no lymph node enlargement and no definite tracheal tug. The heart was displaced to the left so that the apex impulse was felt in the axilla. There were no signs of aortic insufficiency. There was, however, a systolic murmur at the apex. The abdomen and extremities were negative. There was no anemia. The Kahn reaction was positive and the x-ray examination confirmed the diagnosis of atelectasis of the left lung (see Fig. 1). At this time the patient remained on the ward six weeks without any essential changes in

her physical signs—no fever, but a slight cough without expectoration. The pain became less intense and she left the hospital. Two months later she was readmitted on account of the symptoms of cystitis. The thoracic signs were the same as on the previous admission except a definite pulsation could now be seen on the left side of the chest in the second, third and fourth costal interspaces. After several weeks the signs of cystitis subsided and she left the hospital once again, to return four

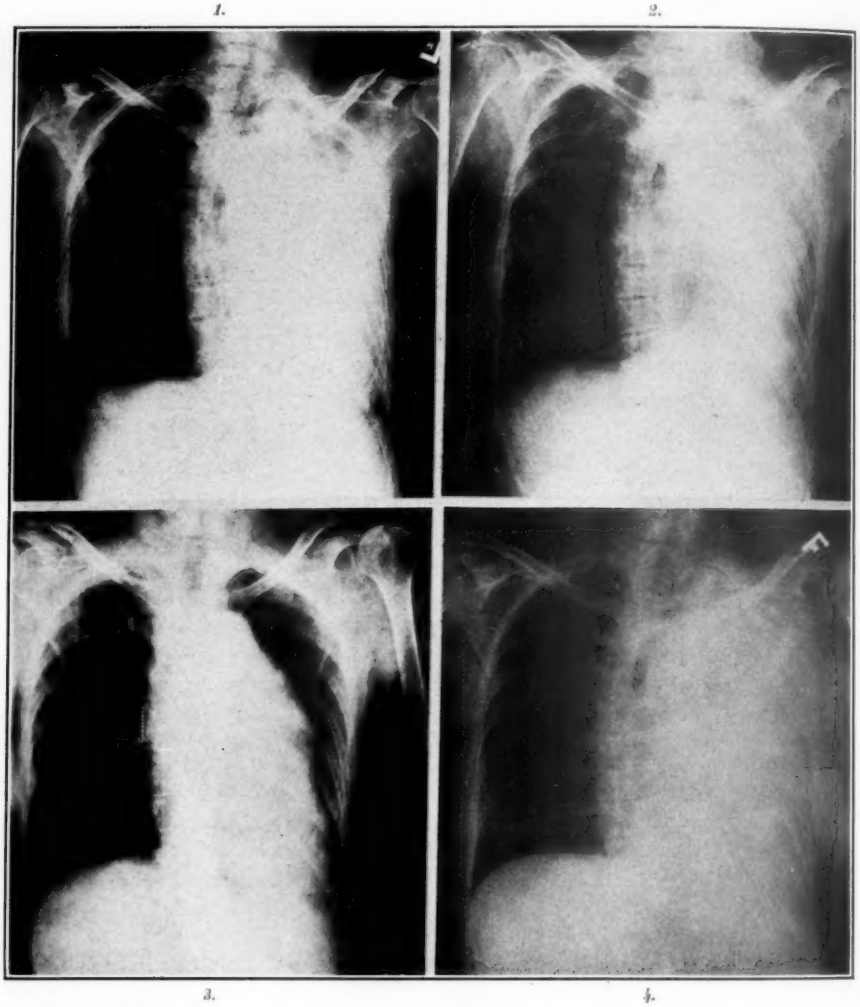

Fig. 1.—(Case 15.) Radiograms of chest taken at different intervals during the course of the illness.

(1) Nine months before death—showing collapse of lung with heart displaced to the left. Partial aeration of left upper lobe. (2) Six months before death—partial collapse of left lung. (3) One month before death—the lung has reexpanded, showing the aneurysm of the descending portion of the aortic arch. (4) One week before death—collapse of lung with signs of fluid at left lower lobe.

months later complaining of shortness of breath and a "cold in the chest." On the first examination she showed the signs compatible with an aneurysm of the aorta, but the signs over the left lung had changed so that the breath sounds were well

heard over the lower lobe. It seemed obvious that the lung had re-expanded, and this was proved by x-ray examination. Later, following an attack of dyspnea, the signs of pulmonary collapse reappeared and were confirmed by x-ray examination. Three weeks before death she had a right-sided hemiparesis, which lasted two days. The day of death she began to cough and, after expectorating large quantities of blood, died. The clinical diagnoses were: (1) syphilitic aortitis; (2) aneurysm of aorta; (3) compression of left main bronchus; (4) atelectasis of left lung; (5) obliterative endarteritis of vessels of arch of aorta with complete occlusion of left common carotid and stenosis of the other branches; (6) rupture of aneurysm into left bronchus.

These diagnoses were confirmed by necropsy, and Fig. 2 shows the area of bronchial compression, together with the point of rupture.

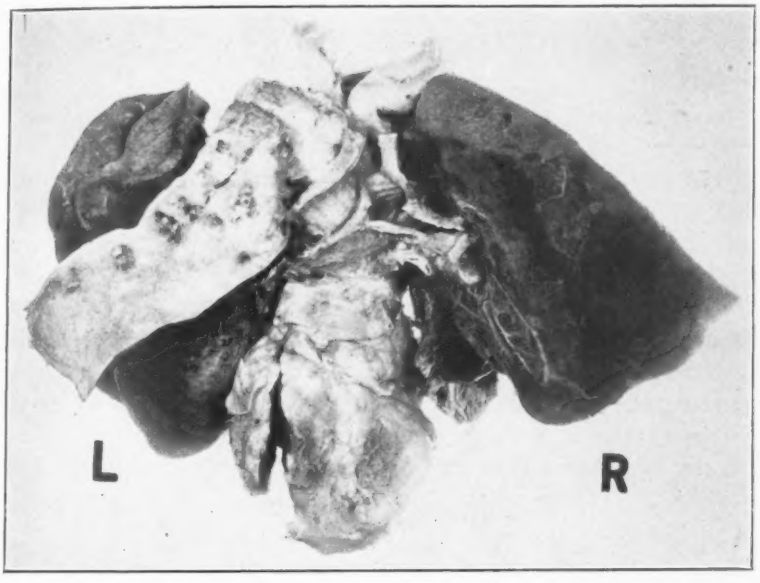

Fig. 2.—(Case 14.) Photograph showing compression and rupture of left main bronchus by aneurysm of descending arch of aorta. The left lower lobe is collapsed. The photograph was taken to show the posterior aspect of bronchi, heart and lungs.

From this case it is evident that recurrent collapse of the lung may follow bronchial compression due to aneurysm of the aorta. In other cases, an infection of a part of the lung which is supplied by the compressed bronchus is the predominating lesion as in Case 14.

CASE 14.—*A man with an aneurysm of the descending arch of the aorta has fever, leucocytosis, signs of bronchial compression and bronchiectasis of the left lower lobe. Death due to infection.*

An emaciated white man, forty-five years of age, complained of cough and shortness of breath on exertion, of six months' duration. For five months he had had attacks of coughing, accompanied by expectoration of mucoid material. There had been loss of weight, dizziness upon rising, pain over the precordium coming on in paroxysms unrelated to exertion and referred to the left shoulder. For six weeks his symptoms had been worse, and he had been bedridden most of this time.

Upon examination his temperature was 104° F., pulse rate 130 and respirations 27 per minute. The cough was paroxysmal in nature and the sputum was mucopurulent. The right lung was clear, the left showed signs of bronchial compression, especially over the left lower lobe where there were râles and distant breath sounds of a wheezing character. There was a tracheal tug when the trachea was displaced to the left side. The red blood cell count was 3,700,000 per cubic millimeter, the hemoglobin 65 per cent, the white blood cell count 18,300 with 76 per cent polymorphonuclear leucocytes. The Wassermann reaction was positive, and there was a mediastinal mass which did not pulsate when examined by the fluoroscope.

During the entire period of observation which lasted three weeks, there was irregular fever varying from 100° to 103° F.; the signs in the chest persisted and the patient continued to lose weight. Death resulted from infection.

From these two cases it is seen that bronchial compression may produce either collapse of the lung or a chronic infection with bronchiectasis. In either case the pulmonary symptoms and signs may predominate.

Rupture Into Pleural Cavity or Lung.—There were three cases (16-18) in which the aneurysm ruptured into the pleural cavity or lung. In one case the aneurysm invaded the left lung directly, and the outstanding feature of the case was recurrent hemoptysis. In the other two cases a hemothorax occurred, and the patient continued to live for some days or weeks before dying. A hematoma following the rupture of an aneurysm may be localized so as to simulate a malignant tumor,[9] or it may be so large as to be confused with a hydrothorax. The latter condition occurs as a complication of an aneurysm following the collapse of the lung or compression of the azygos or pulmonary veins. The fluid in these cases has the characteristics of a transudate and is more commonly left-sided. Case 16 illustrates the course of events when an aneurysm ruptures into the right pleural cavity.

CASE 16.—*A man with a right hemothorax due to an aneurysm of the ascending arch of the aorta dies as a result of hemorrhage into pericardium.*

A colored man, thirty-eight years of age, complained of pain in the right side of his chest. He had been well until ten days before admission, when he noticed a dull aching pain in the right side of his chest in the posterior axillary line which was exaggerated by respiratory effort. The day before admission the pain became more severe, dyspnea and orthopnea were present, and there was an increased amount of coughing with white, frothy, blood-streaked sputum. The past history was irrelevant.

Upon examination the temperature was normal, pulse rate 100 per minute, respirations 28 and the blood pressure was 90 mm. Hg systolic and 70 mm. Hg diastolic. He was well developed, somewhat malnourished, orthopneic, and uncomfortable on account of pain and dyspnea. The pupils were normal. The trachea was deviated to the left but there was no tracheal tug. The carotid and radial pulses were equal in volume. There were signs of fluid in the right pleural cavity, the percussion note being flat and the breath sounds absent. The left lung presented normal signs. The heart was displaced to the left but there were no murmurs. Examination of the abdomen and extremities revealed nothing abnormal.

A needle was inserted into the right pleural cavity and about 50 c.c. of bloody fluid were withdrawn. Cultures of the fluid were negative, and the inoculation of this material into guinea pigs did not reveal tuberculosis. The white blood count was 28,200 per cubic millimeter with 94 per cent polymorphonuclear leucocytes. The hemoglobin was 60 per cent. The blood Wassermann reaction was negative. The sputum contained no tubercle bacilli. X-ray examination of the chest showed a homogeneous density of the lower two-thirds of the right chest. The temperature varied between 99° and 101° F. Repeated physical examinations of the chest revealed no changes. Later attempts to remove fluid from the pleural cavity were unsuccessful. The cough persisted and increased in intensity. Suddenly the patient became more dyspneic, the pulse rate rose, the blood pressure fell, and he died one hour after the onset of the change in symptoms.

Anatomical Diagnoses: Aneurysm of the lateral aspect of the ascending arch of the aorta; hemothorax; hemopericardium.

In summary, a man with pain in the chest, increasing cough and dyspnea, signs of pleural effusion on physical examination, bloody fluid obtained by thoracentesis, sudden collapse and death two months after onset of symptoms.

When the lung is invaded directly by the aneurysmal sac, there may be collapse or perforation of the lung as in Case 17. This is much more likely to occur with an aneurysm of the descending thoracic aorta where it comes in close proximity to the left lung. Another part of the lung that may be compressed is the right or left upper lobe. The signs produced by direct invasion of the lung are repeated hemoptysis or the signs of pulmonary collapse.

Pulmonary and Pleural Tuberculosis.—Tuberculosis was present in three cases. In one there was tuberculosis of the pleura due to an extension from Pott's disease. In the other two the lesions were located in the lung and were incidental findings. The tuberculosis did not occur in collapsed areas due to bronchial compression. The association of aneurysm and tuberculosis has been commented upon previously by Kortz,[13] who collected twenty-two cases of aneurysm in combination with pulmonary tuberculosis. In the cases reported by Kortz,[13] and also by Fraenkel[5] and by Williams[8] the tuberculous lesions were mostly left-sided and occurred more often when the bronchi were compressed. In four of Kortz's reported cases the tuberculosis was right-sided, and in each instance the bronchus was compressed. It is plain, however, from a study of other cases that tuberculosis of the lungs may occur in association with aneurysm without bronchial compression. Its presence, therefore, is probably a coincidental finding and has nothing to do with bronchial compression.

From the cases presented it is evident that aneurysms of the aorta frequently produce pulmonary or pleural complication through compression of the trachea, bronchi or lung, or through rupture into the lung or pleura. These features may dominate the clinical picture in such a way that the primary cause of the disturbance is overlooked.

SUMMARY

1. Twenty-two cases of aneurysm of the aorta showing conspicuous pulmonary or pleural complications are summarized.

2. Pulmonary complications, such as atelectasis, bronchopneumonia, organizing pneumonia, abscess or bronchiectasis, arise as the result of tracheal or bronchial compression or of direct invasion of the lung.

3. Pulmonary tuberculosis occasionally accompanies aneurysm of the aorta, with or without bronchial compression.

4. Pleural complications arise as a result of rupture of the aneurysm into the pleural cavity and compression of the pulmonary or azygos veins, or from extension of an infection from an underlying pulmonary lesion.

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TOTAL THYROIDECTOMY IN ANGINA PECTORIS

An Experimental Study*

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STRIKING clinical results have been reported recently from the complete removal of the normal thyroid gland in cases of severe angina pectoris.[1, 2] The mechanism, however, by which total thyroidectomy relieves these patients is not at all clear. The beneficial effect of thyroidectomy in the case of decompensated heart disease has been regarded as due to the resulting lowered metabolism with slowing of the circulation and consequent lessening of the burden on the heart. A close correlation has been observed in these cases between the level of the metabolism and the cardiac condition, the improvement taking place as the metabolic demands fall. This cannot be the entire explanation in angina pectoris, however, for here a beneficial effect has been observed almost immediately after operation, whereas the basal metabolic rate does not begin to fall for over a week. The following animal experiments were undertaken in the hope of assisting in the elucidation of this problem.

It has been known for some time that it is possible to produce a definite response in the unanesthetized dog by interfering mechanically with the coronary blood flow,[3, 4, 5] and this response has been of such a nature as to convince observers that the dog experiences a sensation comparable to anginal pain in man. The experimental procedure, as described by Sutton and Lueth, consists in passing a ligature around the descending branch of the left coronary artery and bringing this out of the chest through a glass tube about which the pericardium and chest wall are closed. After the animal has recovered from anesthesia, traction on this suture compresses the vessel and the definite pain reaction is evoked.

The fact that the therapeutic effect of total thyroidectomy is observed in some cases almost immediately after operation has suggested the possibility that the procedure may in some way interfere with the sensory nerve impulses from the heart.[6] White and his associates[7] recently reported studies on the effect of severing various components of the sympathetic nervous system on the subsequent production of cardiac pain in dogs by the method of Sutton and Lueth. They found that the

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painful response was prevented by appropriate procedures on the sensory nervous pathways at a preliminary operation. We have similarly tested the effect of thyroidectomy upon this pain response.

METHOD

The method was essentially the same as that described by Sutton and Lueth.[5] Under intratracheal ether anesthesia the anterior half of the fifth rib on the left was resected, the pleura was opened and a small incision made in the pericardium over the tip of the left auricle. An "E" silk suture was passed around the anterior descending branch of the left coronary vessels at this point by means of a blunt aneurysm needle and the suture brought out through a flanged glass tube. We endeavored to devise a method whereby the suture could be left in situ and the

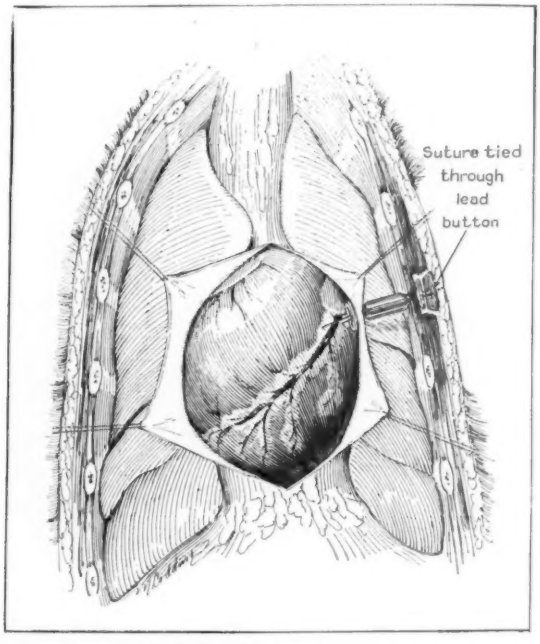

Fig. 1.—Drawing showing method for leaving coronary suture in situ, used in dog C-322.

animal retested for the pain response from time to time after thyroidectomy. This was successfully accomplished in one animal by using a short double-flanged glass tube the outer end of which was buried under the skin and subcutaneous tissues and the ends of the coronary suture anchored under the skin by a lead button (Fig. 1). At the completion of the initial operation the center of the skin wound was left open and sterile dressings were applied. Four or five hours later the dressings were removed, and the test for the pain reaction was carried out by pulling on the coronary suture with sterile instruments. The skin was now closed over the lead button and a collodion dressing applied. The test was repeated at a later date by simply making a small incision over the button under novocaine infiltration and applying traction to the coronary suture. It was found that the typical reaction could be elicited by this method quite as readily as with the proximal end of the glass tube pressed against the heart for countertraction as described by previous

experimenters. However, the procedure was found to be generally impracticable since there was invariably a low-grade fibrinous pericarditis which frequently plugged the glass tube involving the suture in organized tissue and preventing further observations. In several instances the artery became thrombosed producing an infarction of the myocardium, and in one dog the suture pulled out of the heart after occlusion and infarction had taken place. In two dogs the pleural space over the heart was obliterated by suturing the pericardium to the pleura as a preliminary operation, hoping thus to obviate the glass tube. This, however, resulted in an epicardial reaction which obliterated the landmarks, preventing an accurate placing of the coronary suture. Further efforts to leave the coronary suture in situ were abandoned, since it was felt that a preliminary control observation was not essential.*

The thyroidectomy was performed under intraperitoneal sodium pentobarbital anesthesia. Both glands were removed including the parathyroids, one or two of which were reimplanted into the sternothyroid muscle. The animals were maintained in good condition by the preoperative administration of viosterol, twenty drops daily for from ten to fourteen days,[8] and postoperative calcium lactate 25 grams by stomach tube daily.[9]

We wish to emphasize the fact that in testing for cardiac pain the animals were not allowed to suffer needlessly. In each instance the traction on the coronary suture was released as soon as it was apparent that the typical reaction was being produced. It was found to be unnecessary to carry the stimulation beyond the point of only moderate discomfort.

OBSERVATIONS

The test for cardiac pain was made in two dogs both before and after thyroidectomy; in one this was accomplished by leaving the coronary suture in situ, and in the other by removing the suture and glass tube after the first observation and replacing them at the time of the second observation. In both dogs no demonstrable change in the response was noted after thyroidectomy.

Dog C-322. Nov. 4, 1933. Intratracheal ether anesthesia. Suture placed about coronary vessels as described above and threaded through double-flanged glass tube, the outer end of which was buried in the subcutaneous tissue. (Fig. 1.) Five hours later the animal was completely recovered from anesthesia, and traction on the suture produced definite evidence of pain on repeated observations. Wound closed; uneventful recovery.

Nov. 10, 1933. Complete thyroparathyroidectomy with reimplantation of two parathyroids into neck muscle. Moderate tetany for two days controlled with calcium.

Two weeks later. Under novocaine infiltration wound was opened over the lead button, and coronary suture readily was identified. Traction on suture again evoked the unmistakable pain response.

Six weeks after thyroidectomy. Test repeated as above, but now no response could be elicited by traction on coronary suture. Animal was sacrificed, and autopsy revealed that suture had torn out of heart and was held in fibrous pericardial

*We have found, in accord with previous observers, that the pain reaction always occurs in the normal animal provided that it is reasonably recovered from the anesthetic and that the suture includes the coronary vessels. It appears to matter little whether both the artery and vein have been included. Our suture usually compressed both vessels, but we have found that the typical reaction occurs on compression of either the artery or the vein alone.

adhesions. Surface of heart was covered with a thick, gray, jellylike exudate lying between bands of fibrous adhesions. The anterior descending coronary vessels were patent only down to the previous site of the suture and were thrombosed below this point. No gross myocardial infarction, however.

C-9. Jan. 12, 1934. Anesthesia—intratracheal ether. Suture of waxed "E" silk placed about coronary vessels as described above and threaded through a long single-flanged glass tube. Pericardial and chest wounds were tightly closed with care to remove pneumothorax. Femoral artery was cannulated for blood pressure tracings and tambour attached to chest for recording respirations. Anesthetic ceased and intratracheal tube was removed. *Thirty minutes later* dog was alert and responded in the typical manner to traction on the coronary suture. Animal was then re-etherized, intratracheal tube replaced, and glass tube with coronary suture removed. Uneventful recovery.

Jan. 23, 1934. Total thyroparathyroidectomy with reimplantation of one parathyroid into neck muscle. Dog suffered moderately severe tetany for ten days, not controlled with calcium orally and intravenously, and finally relieved by parathormone 0.5 c.c.*

Twelve days after thyroidectomy, under intratracheal ether anesthesia, chest was reopened and suture again placed about coronary vessels at the same site as before.

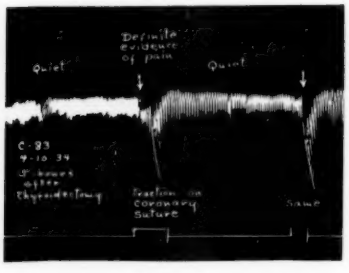

Fig. 2.

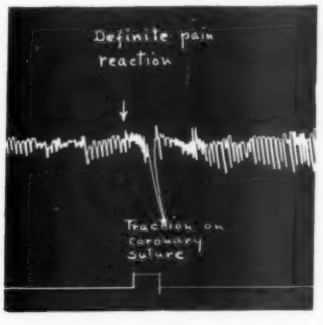

Fig. 3.

Fig. 2.—Tracing from dog C-83 showing typical response to traction on coronary suture five hours after thyroidectomy.

Fig. 3.—Tracing from dog C-12 showing typical response four weeks after thyroidectomy.

Chest was closed about glass tube. Anesthetic removed. *Thirty minutes later* the animal was alert and responded exactly as before to traction on coronary suture.

In three dogs no effort was made to test the reaction to coronary occlusion before thyroidectomy.

C-83. April 10, 1934. Morphine 0.015 grams, and intratracheal ether. Coronary suture was placed as in previous experiments and thyroparathyroidectomy performed.

Five hours later traction on the suture evoked the typical response with stiffening of the forelegs and restlessness. (Fig. 2.)

C-351. Oct. 30, 1933. Total thyroparathyroidectomy with reimplantation of four parathyroids into right neck muscle. No subsequent tetany.

Two weeks later coronary suture was placed as in previous experiments. Four hours later a definite pain reaction was produced by moderate traction on the suture.

*This was the only instance in which the viosterol and calcium regime was not effective.

C-12. Jan. 30, 1934. Total thyroparathyroidectomy with reimplantation of two parathyroids into neck muscle. Slight subsequent tetany controlled with calcium.

Four weeks later coronary suture was placed as described above. Thirty minutes after withdrawal of anesthesia traction on the coronary suture produced the typical pain response which was immediately relieved by release of the tension (Fig. 3).

It must be borne in mind, in considering these negative results on the effect of thyroidectomy, that dogs do not react to ablation of this gland in the same way as do human beings. The fall in metabolism is only temporary, the circulatory rate* is unchanged (Fig. 4), and a condition resembling clinical myxedema is very rarely observed. This is probably due to a compensatory hypertrophy of the accessory thyroid tissue which is found almost universally in the dog, scattered about the neck and upper mediastinum.[10] However, the fact that the typical response to

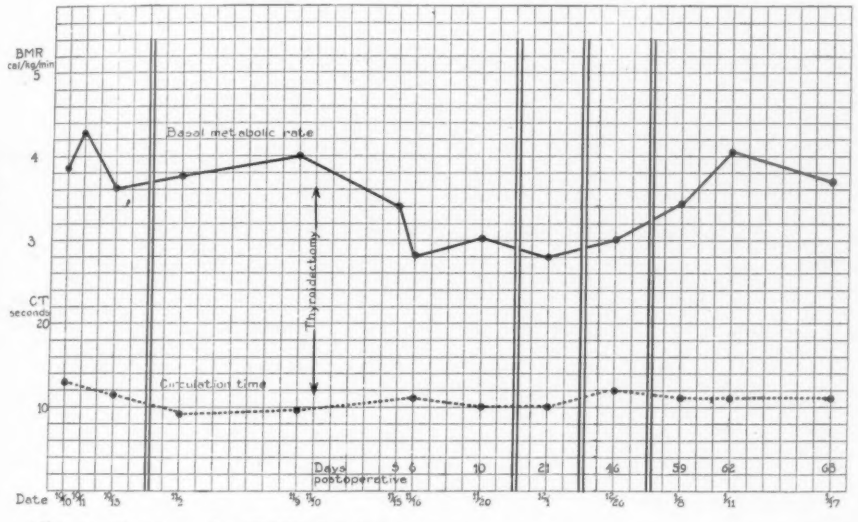

Fig. 4.—Chart on dog C-322 showing:
(1) Spontaneous recovery from hypothyroidism due to compensatory hypertrophy of accessory thyroid tissue.
(2) Circulation time remained unaltered in spite of a marked fall in metabolic rate.

temporary mechanical coronary occlusion can be elicited after thyroidectomy as well as before, indicates that the sensory pathways of the heart are still intact.†

COMMENT

A possible explanation of the early and dramatic change seen in angina pectoris cases after removal of the thyroid has been suggested by the

*The sodium cyanide method was used, the interval recorded between the time of injection in the femoral vein and the first deep inspiration.

†It is true that after thyroidectomy there may have been slight differences in the degree of traction required to elicit the pain response, or in the severity of the response to a given amount of traction. The limitations of the experimental procedure make it impossible to determine such minor quantitative changes. The exact experimental conditions cannot be reproduced a second time in a given animal, and the response to a certain measured amount of traction in different dogs is subject to unavoidable experimental and temperamental variations.

clinical observation of a change in reaction to adrenalin after operation. Eppinger and Levine[11] found that the rise in blood pressure and pulse rate induced by the intramuscular injection of 0.3 to 0.5 c.c. of 1:1,000 adrenalin was definitely diminished when the test was repeated from one to five days after total thyroidectomy; and that whereas the injection provoked an attack of angina before operation, the attack did not occur postoperatively. These authors suggested that this altered reaction to adrenalin might be responsible for the relief of anginal pain.

The interrelationship between the thyroid and the adrenals has been repeatedly demonstrated during the past twenty-five years in experimental animals. The glycosuric response to injected adrenalin has been found to be diminished after thyroidectomy.[12] Similarly the vasopressor response to adrenalin has been observed to be less after thyroidectomy[13] and to be augmented after increasing the activity of the thyroid by electric stimulation[14, 15] or after feeding thyroid.[16] The tachycardia response to adrenalin in the isolated perfused heart has been found to be increased by thyroxin[17] and decreased after previous thyroidectomy.[18] This last observation has been corroborated recently by experiments on the denervated heart preparation of Cannon.[19]

We have studied the effect of thyroidectomy on the vasopressor action of adrenalin in dogs and found a definitely diminished response in two dogs when tested three and four weeks after thyroidectomy. However, three other dogs tested one, two, and six weeks after thyroidectomy failed to show this change. The individual variation in this regard may be due to the presence of varying amounts of accessory thyroid tissue.

The beneficial effect of removal of the thyroid gland in angina pectoris may be due, in part at least, to a diminished effectiveness of the physiological output of adrenalin. This explanation would imply that the paroxysms of anginal pain in patients with coronary artery disease may be caused by an increase from time to time in the individual's output of adrenalin. Such a concept does not seem entirely unreasonable when we reflect that the physical and emotional changes which precipitate attacks of angina are just those which have been shown experimentally to cause an outpouring of adrenalin into the blood stream.[20] It has been demonstrated that injected adrenalin will generally initiate an attack in patients suffering from angina pectoris;[21] so it is quite conceivable that a sudden increase in the secretory activity of the adrenals might have a similar effect in these patients.

There are two ways in which adrenalin, either secreted or injected, might precipitate an attack of angina. First, it might cause a constriction of the coronary arteries which would directly produce the myocardial ischemia. Second, it might, by raising the blood pressure and heart rate, so increase the vascular demands of the myocardium that in

the presence of a preexisting narrowing of the coronary artery or of a rigidity preventing a compensatory dilatation, cause a relative myocardial ischemia.

Although there is some evidence that adrenalin may constrict the coronary arteries in man,[22] this action has not been definitely established, and indeed it would seem a perverted mechanism which would curtail the supply of blood to the heart muscle just at that time when it is most needed. Moreover the atheromatous condition of the coronary arteries, which is frequently observed postmortem in patients suffering from angina pectoris, makes it improbable that in these patients an active vasoconstriction could have been the cause of the attacks.

On the other hand, there is considerable clinical evidence that an increase in the work of the heart may be the precipitating factor in many cases of angina. There have been reported recently several careful clinical studies[23, 24, 25] which indicate that a rise in blood pressure and increase in heart rate are very frequently associated with the attack of angina, and some clinicians have ventured the opinion[24, 25] that these circulatory changes do not take place as a result of the painful attack, as has been believed, but are rather the immediate cause of the attack.

The "experimental angina" produced in dogs by Sutton and Lueth's method depends upon a constriction of the coronary vessels, with the demands of the heart muscle remaining constant; however, as we have demonstrated, there are certain objections to the clinical application of this mechanism. In a previous communication[26] experimental observations have been presented describing a method for eliciting the same pain response in the unanesthetized dog by suddenly increasing the work of the heart in the presence of a constant slight narrowing of the coronary vessels. This was accomplished by establishing a constant subminimal pull on the coronary ligature by means of a weighted cord and then injecting a vasopressor dose of adrenalin into the femoral vein. The reaction which has been found to indicate cardiac pain in the dog was observed to occur coincidental to the rise in blood pressure. Adequate control studies showed that the subminimal traction alone or the adrenalin alone would not cause pain.

We have studied the effect of thyroidectomy upon the production of cardiac pain by the above method. Although it was possible to elicit the response in thyroidectomized animals, it soon became apparent that the experimental method did not lend itself to an accurate evaluation of this factor. One difficulty was that the vasopressor response to a given dose of adrenalin differed so widely in the various dogs tested that it would have been necessary to repeat the test for cardiac pain before and after thyroidectomy in the same animal. It was obviously impossible

to reproduce the experimental conditions a second time in the same dog with sufficient accuracy to warrant definite conclusions. Even if the suture were successfully left in situ, the local reaction in the cardiac tissue would inevitably alter the amount of tension required to produce a given amount of constriction.

SUMMARY

Thyroidectomy does not alter the pain response in dogs produced by mechanical interference with the coronary blood flow.

The possibility is discussed that the beneficial effect of total thyroidectomy in angina pectoris may be due to an interference with the thyroadrenal mechanism.

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INTERLOBAR EFFUSIONS IN PATIENTS WITH HEART DISEASE*

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INTRODUCTION

EFFUSIONS in the interlobar spaces of the lungs are much more frequent in patients with heart disease than has been considered heretofore. The diagnosis was not made with any degree of certainty until correlated studies with x-ray and autopsy findings were made.[1, 2] Since then several individual case reports[3–8] of such effusions occurring in the course of congestive heart failure have appeared in the literature.

We have reviewed the clinical course of 18 patients with interlobar effusions who have been on the wards of Montefiore Hospital since 1930, and in this study we wish to stress the comparative frequency with which the condition is encountered and its relationship to the general problem of myocardial insufficiency.

PATHOGENESIS

On purely theoretical grounds, any inflammatory reaction which involves the lung parenchyma or the pleura may give rise to an interlobar effusion, provided the disease process is close enough to the fissure. In heart disease the effusion may arise as an exudate from a pleurisy or pericarditis in the course of active rheumatic fever; it may follow an infarction along a pleural surface, or it may occur during cardiac decompensation. The reason for the localization in the latter condition is not quite so apparent, because here it is the result of transudation from congested lungs and pulmonary stasis, a purely mechanical process.

In the pathological studies of Steele,[5] Keiser,[3] and Austrian,[8] the outstanding finding was an adhesive pleurisy which completely obliterated the pleural sac except in the area destined to house the fluid (the interlobar region). These writers concluded that fluid entered into the interlobar space during congestive failure for one very simple reason—it had no other place to go. In most of the cases reviewed, as in ours, an antecedent history of pneumonia or pleurisy could not be elicited to explain the obliteration of the pleural sac. However,

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pleural reactions are very common in decompensated cardiacs and, as a result of repeated bouts of failure, they lead to thickenings which become appreciable radiographically in the costophrenic sinuses and interlobar fissures, and may go on to the formation of adhesive bands between the two pleural layers. It seems logical to attribute the picture to pleuritides of this nonspecific nature, upon which are often superimposed congelation and fibrin deposition from chest fluid as a result of chronic stasis.

The interlobar fissure appears to be least affected by these pleural reactions for several reasons: first, because pleurisy most commonly involves the two layers forming the free pleural cavity; second, with respiration a pleuritis spreads very easily by contiguity as a moving structure (the lung) expands and contracts against the relatively fixed costal cage. The pleura on either side of the interlobar fissure, however, tends to remain in contact. Third, drainage of fluid from the interlobar region is facilitated by the two areas of lung surface in contact with it, while drainage from the pleural cavity cannot be so efficient, as the effusion is bounded on one side by the chest wall. Fourth, the amount of fluid is generally much less than in the free pleural cavity; hence resorption is again more rapid and more complete.

While this undoubtedly explains the well-marked cases with typical textbook appearance, there exists another and more common group. Here the obliterative pleurisy is not at all prominent, and transudation of fluid takes place both into the general pleural cavity and into the interlobar pleural space. The hydrothorax rising in the chest cavity indents the pleura and lung tissue on either side of the fissure due to mechanical pressure, and additional fluid seeps into the interlobar pleural space. At times it is difficult to differentiate between these two layers of fluid. Studies of such cases have made us suspect that in many patients with cardiac decompensation, in whom hydrothorax of the general pleural cavity occurs, there is at the same time an effusion in the interlobar space.

ANATOMY AND ROENTGENOGRAPHY

A knowledge of the anatomy of the interlobar fissures is essential for a clear understanding of the physical changes that are encountered. On each side there is an oblique fissure which transects the lung almost to the hilum, and a transverse fissure which lies only on the right side, separating the upper from the middle lobe of that lung. As Brown[9] points out: "each oblique fissure is at right angles to the lateral chest wall, while the transverse fissure is at right angles to the anterior chest wall. Hence thickening or fluid in the oblique fissures is best observed in the lateral view; whereas thickening or fluid in the horizontal fissure is most readily recognized in the anteroposterior position." (Fig. 1.)

The radiological picture depends upon the position of these pockets of fluid, whether they lie closer to the anterior, the posterior, the medial or the lateral portion of the fissure. The x-ray diagnosis has

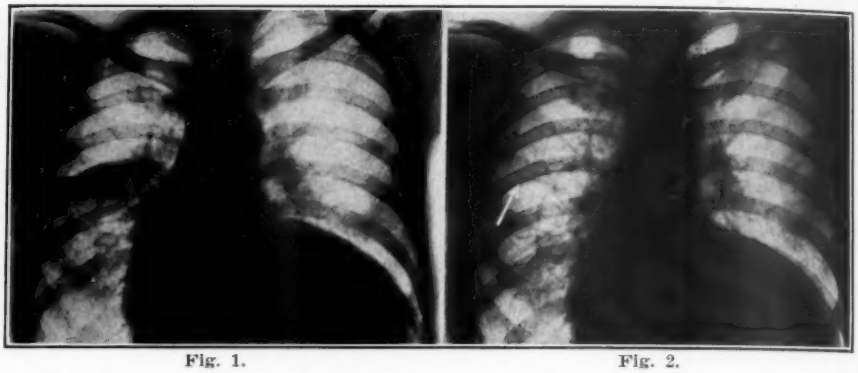

Fig. 1. Fig. 2.

Fig. 1.—Case 1, admission plate showing large effusion in the transverse fissure.

Fig. 2.—Case 1, after one week of diuretic therapy; only an interlobar fissure scar remains.

Fig. 3. Fig. 4.

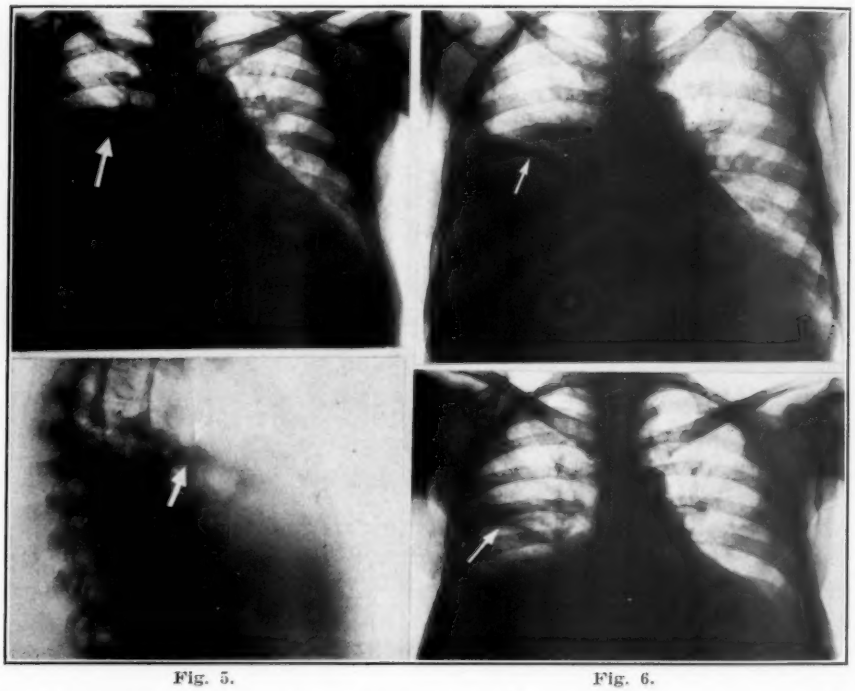

Fig. 5. Fig. 6.

Fig. 3.—Case 2, on admission, in the x-ray film fluid in the general pleural cavity obscures the interlobar effusion which is present. Satisfactory evidence of its presence was revealed by fluoroscopy.

Fig. 4.—Case 2, after one week of diuretic therapy.

Fig. 5.—Case 2, lateral view taken at the same time as Fig. 4, to show the relation of the effusion to the interlobar fissure.

Fig. 6.—Case 2, general clearing two to three weeks after diuretic therapy. Only a thin layer of fluid remains in the interlobar fissure with much more in the free pleural space.

been too well described to warrant detailed description in this communication, suffice it to say that the shadow may be band-shaped, wedge-shaped, elliptical or round, depending upon the amount of distention and the area of pleural surface involved. Bending for-

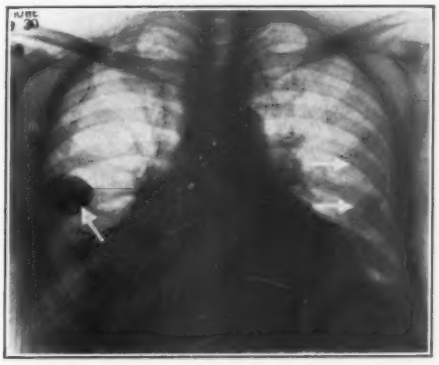

Fig. 7.—Case 6, sacculated effusion in the transverse fissure. The white arrows indicate the fractured ribs on the opposite side.

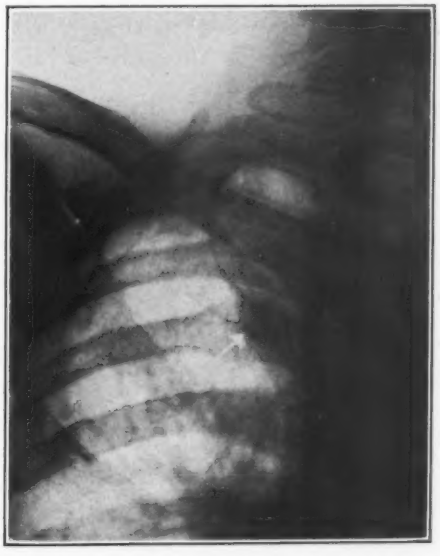

Fig. 8.—Case 14, effusion into the fissure between the azygos and upper lobes of the right lung.

ward, backward, or from side to side, frequently will accentuate the shadow of an interlobar effusion.

REPORT OF CASES

The patients were all chronic cardiac individuals. They were studied by combined fluoroscopic and roentgenographic examination,

TABLE I

INTERLOBAR EFFUSIONS AS A RESULT OF TRANSUDATION

CASE	DIAGNOSIS	FINDINGS	AFTER THERAPY	COMMENT
No. 1 C. B. 36, 0	CRCVD, MI, MS, AI, AS,* complete a-v dissociation, congestive failure.	Ovoid effusion into transverse fissure (Fig. 1). Diaphragmatic adhesions and obliteration of costophrenic angle present—indicate the extensive pleural reactions which result from long-standing decompensation.	Complete disappearance of effusion (Fig. 2): Note thickened interlobar pleura.	When taken off diuretic measures, symptoms returned. Daily fluoroscopic studies showed dramatically the reaccumulation of interlobar fluid. Therapy again produced resorption.
No. 2 S. H. 44, 0	CACVD,† hypertension, diabetes mellitus, R.S.R., congestive failure.	Homogeneous density throughout right lower chest revealed by x-ray picture; by fluoroscopy, however, a denser layer above the free fluid in region of transverse fissure was observed (Figs. 3, 4, 5).	Resorption first in interlobar region and to a lesser degree from general pleural cavity. Marked clearing about two to three weeks after admission. (Fig. 6.)	Coexistence of effusion in different locations is here demonstrated. Chest fluid in individuals with myocardial failure will fill all the potential spaces, if present in sufficient quantity.
No. 3 I. L. 30, 0	Congestive heart failure, R.S.R., etiology?	Small sacculated effusion into transverse fissure.	Disappearance, leaving only faint scar.	Reappearance and resorption of interlobar fluid in subsequent breakdowns with same diuretic measures.
No. 4 G. S. 22, 0	CRCVD, MI, MS, AI, AS, auricular fibrillation, congestive failure.	Free fluid in right chest extending into transverse fissure and limited from going above this by pleura adherent to lateral chest wall.	Disappearance of free and interlobar fluid.	
No. 5 S. L. 56, 0	CACVD, hypertension, intraventricular conduction disturbance, congestive failure.	Free pleural fluid with small effusion into transverse fissure.	Almost complete resorption.	
No. 6 J. D. 60, 0	CACVD, hypertension, R.S.R, auricular flutter, congestive failure.	Extensive pleural thickening in lower right chest with small, rounded effusion tapering at the ends, representing an effusion into the transverse fissure. (Fig. 7.)		Three broken ribs were present on left side and these, in association with the round shadow, might have been diagnosed as pulmonary neoplasms with metastases and pathological fracture.

*CRCVD, Chronic rheumatic cardiovalvular disease; MI, mitral insufficiency; MS, mitral stenosis; AI, aortic insufficiency; AS, aortic stenosis; R.S.R., regular sinus rhythm.

†CACVD, chronic arteriosclerotic cardiovascular disease.

TABLE I—CONT'D

CASE	DIAGNOSIS	FINDINGS	AFTER THERAPY	COMMENT
No. 7 S. M. 62, 0	CACVD, congestive failure, R.S.R., pulmonary emphysema, chronic bronchitis.	Moderate increase in lung markings due to congestion. Small effusion, hemisperical in shape, into transverse fissure.		
No. 8 M. L. 63, 0	Hypertensive heart disease, R.S.R., congestive heart failure.	Small amount of fluid and pleural thickening in right costophrenic angle. Saccu-lated effusion into transverse fissure.	Markedly decreased.	
No. 9 A. D. 63, 0	CACVD, multiple myocardial infarcts, R.S.R., congestive heart failure.	Free fluid in right chest dipping into transverse fissure. Thickening in left costophrenic angle.	Complete disappearance.	
No. 10 B. S. 33, 0	CRCVD, MI, MS, R.S.R., congestive failure.	Moderate amount of fluid at right base with thin bandlike layer in transverse fissure.		Appears nicely in contrast to layer of fluid which extends over it from general pleural cavity.
No. 11 E. P. 43, 0	Acromegaly, osteitis fibrosa cystica, R.S.R., CACVD.	Thin band of effusion into transverse fissure.		No other sign of decompensation present.
No. 12 E. W. 40, 0	CRCVD, MI, MS, auricular fibrillation, congestive heart failure.	Small amount of fluid at right base with thin ribbon of fluid into transverse fissure.	Interlobar scar and thickening in both costophrenic angles.	
No. 13 M. deP. 14, 0	CRCVD, MS, AS, AI, R.S.R., congestive heart failure.	Marked thickening of left oblique fissure in lateral view.		Fissure involvement of left side is unusual. In this case the anteroposterior view is negative.
No. 14 J. N. 49, 0	CRCVD, AI, AS, MI, MS, R.S.R., cardiac decompensation.	Extensive pleural effusion at right base and a thin film extending along the lateral chest wall to the apex and dipping into the fissure of the azygos lobe (Fig. 8).	Resorption by tap and diuretic therapy.	This case is unique. The azygos lobe is an anatomical anomaly and its association with interlobar effusion is even more rare.[10]

TABLE II

INTERLOBAR EFFUSIONS AS A RESULT OF EXUDATION*

CASE	DIAGNOSIS	FINDINGS	AFTER THERAPY	COMMENT
No. 15 B. F. 36, 0	Chronic diffuse glomerular nephritis (nephrotic stage), hypertension, enlarged heart, anasarca.	After admission, patient developed an inflammatory process in right lower chest with effusion into adjacent transverse fissure.	With recovery from acute infection and restoration of compensation, both lung fields became clear.	Interlobar fluid here appears to be due to a combination of three factors: (1) inflammatory reaction from bronchopneumonia (?), (2) mechanical transudation, and (3) capillary wall damage.
No. 16 R. E. 40, 0	Rheumatic polyarthritis, auricular fibrillation, R.S.R., erythema multiforme.	Diffuse pleuritis in lower left chest. Small oval effusion into oblique fissure. Process progressed with effusion spreading to general pleural cavity (Fig. 9).	Upon subsidence of activity, the interlobar effusion cleared up. Free fluid removed by tap.	The effusion and its unusual location are on basis of a rheumatic pleuritis.
No. 17 R. McC. 41, 0	CRCVD, MI, MS, relative tricuspid insufficiency, R.S.R with extrasystoles, congestive failure, pulmonary infarction	Rough friction rub in anterior chest on physical examination. Extensive pleural thickening in right costophrenic angle and in interlobar fissure with small amount of fluid in latter.	Gradual improvement.	Pulmonary infarction.
No. 18 S. M. 18, 0	CRCVD, AI, AS, MS, tricuspid insufficiency, first degree heart-block, congestive heart failure, pulmonary infarction.	Area of infarction in right middle lobe with effusion into transverse fissure.	After 5 days beginning resorption; after 24 days complete resorption.	Pulmonary infarction with its presence demonstrated at autopsy.

*Since the original investigation, 8 additional cases have come to our notice. Seven of these belong to the transudative group and one (the result of infarction) falls into the exudative group.

a procedure which is superior to taking plates alone for the detection of effusions which are small or which mingle intimately with shadows produced by other structures in the chest. (The individual case reports are given in table form.) From these tables, it can be seen that interlobar effusions fall into two main groups—the transudative and the exudative types. In the first group are included the single isolated effusions (which develop in the interlobar region because of adhesions closing the general pleural space), and the interlobar effusions coexisting with free fluid in the general chest cavity and representing extensions from it. (Cases 2, 4, 5, 9, 10, 12, 14.) In the exudative type of interlobar effusion we have those resulting from specific inflammatory reactions, such as infarction, rheumatic pleuritis, etc.

These patients illustrate the frank types of interlobar hydrothorax. The most striking thing, however, was to find linear shadows or scars

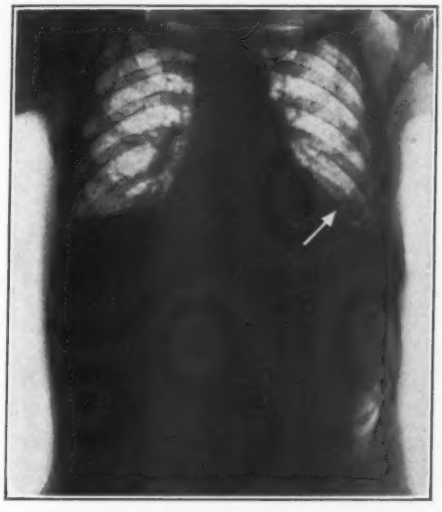

Fig. 9.—Case 16, an interlobar effusion into the left oblique fissure, a very unusual location.

in the interlobar regions of more than 75 per cent of several hundred cardiac patients examined. Because of its position, thickening of the transverse fissure offers such a striking contrast to the surrounding lung as to make it easily recognized. In addition there was usually thickening of the parietal pleura, diaphragmatic adhesions, and obliteration of the costophrenic angles. These structural changes can mean only one thing in the light of a history of repeated bouts of decompensation—that fluid has collected and has been resorbed in these areas on one or more occasions, leaving its sequelae.

DISCUSSION

There are many points of interest about an interlobar effusion aside from its mere physical presence. In nearly all of the cases studied the

effusion was on the right side. This is not at all fortuitous, because it is also true of effusions into the general pleural space. Second, physical signs are comparatively few, and the condition is usually an accidental finding in the teleroentgenogram. Attempts to verify the diagnosis by puncture are extremely unsatisfactory. Their rapid disappearance with treatment is characteristic and refutes the common conception that diuretic measures are of no avail in the mobilization of chest fluid. This in general may be true of the ordinary type of hydrothorax, but it does not apply to interlobar fluid. The difference between the two probably lies in the fact that the total fluid area involved is much less, and that the two areas of lung tissue which bound the fissure form a more active resorption surface.

The relationship of auricular fibrillation and diseases of the aortic valve to this condition has been stressed by certain writers.[6, 8] We feel that these are coincidental and are merely expressions of long-standing cardiac disease associated with decompensation.

Differentially, lung abscesses, tumor nodules or pulmonary infarcts may closely resemble interlobar effusions, and confusing shadows may be cast by the pectoralis and trapezius muscles, or by localized thickening of the pleura in the general pleural cavity. As a rule, however, a density of this sort in a decompensated individual, which seems to melt away with the return of compensation, should present no great diagnostic problem.

SUMMARY

Although interlobar fluid accumulation has a varied etiology, it is most frequently encountered in patients with heart disease. In this condition it may be the end-result of an inflammatory process or, more commonly, it may be the transudative type found in decompensated individuals.

Interlobar effusions arising by transudation differ in no way from those in the free pleural cavity except in location. Some are walled off in the interlobar region by an adhesive pleurisy of the general pleural space; others merely enter the fissure as an extension from a hydrothorax.

In the course of heart failure pleural reactions are very frequent, not only in the interlobar region but also in the free pleural space. Upon resorption, only scars or thickened pleura remain. Whenever such residua are found, it is reasonable to assume that the patient had either preexisting fluid (interlobar or otherwise) or chronic pulmonary stasis.

Interlobar effusions and their pleural thickenings are not roentgenological freaks, but constitute an integral part in the history of chronic cardiac disease.

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ADHESIVE MEDIASTINOPERICARDITIS WITH NORMAL CARDIAC ELECTRICAL AXIS ROTATION ON POSTURAL CHANGE

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EINTHOVEN[1] observed that when the body of a patient was rotated from right to left, a change in the form of his electrocardiogram took place. This change represented a shift in the electrical axis of the heart. Einthoven originally attempted to measure the action current of the beating heart as a succession of vectors. He devised the three leads graphically represented by the sides of an equilateral triangle.

The representations of the ventricular impulses of the three leads, recorded simultaneously, were assumed to record the summation of the electrical potentials of the entire mass of the ventricular muscle. The direction assumed by the vector representing this summated electrical potential was termed the electrical axis. The zero degree position of the circle, from which the axis position was measured, was arbitrarily placed pointing directly caudad. Rotation to the left was indicated as negative degrees and to the right as positive degrees, the maximum being the 180 degree point which lay directly cephalad.

In spite of the failure to record simultaneously all three leads, it has been a generally accepted procedure to estimate this electrical axis by calculation from the algebraical summation of the greatest positive and negative deflections of the QRS complexes in Leads I and III.

The change in the electrical axis with shift of position of the patient was interpreted by Einthoven as being due to a rotation of the heart in the chest about the longitudinal axis of the body. This change has been commonly regarded as being absent in patients with chronic adhesive mediastinopericarditis. By this term we mean that state in which firm, chronic inflammatory adhesions exist between the heart and the pericardium, and between the pericardium and the adjacent mediastinal structures and the chest wall. The belief that axis fixation occurs in this type of pericardial disease is based largely on the observations of Dieuaide.[2] This investigator reported two cases in which at post-mortem examination dense adhesions were found to exist between the heart, the pericardium and the mediastinum. These patients, during life, had

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†We are indebted to Miss Ola Nagle and Miss Jane Wasserman for technical assistance.

shown no shift of the cardiac electrical axis with rotation of the body. Dieuaide's study also included two additional patients in whom there was a very slight axis change and in whom at necropsy there was a moderate fixation of the pericardium and mediastinum. Eight other cases showed clinical signs of adhesive mediastinopericarditis, but normal axis rotation was found. None of these latter eight patients had combined mediastinopericardial adhesions at autopsy, although chronic adhesive mediastinitis or pericarditis may have existed separately. Dieuaide hoped to diagnose only instances of adhesive pericarditis in which adhesions involved both the mediastinum and the pericardial cavity.

The purpose of this report is to show the behavior of the electrical axis of the heart in extensive chronic adhesive pericarditis with medi-

TABLE I

ROTATION OF THE ELECTRICAL AXIS OF THE HEART IN NORMAL SUBJECTS

SUBJECT	SEX	AGE (YEARS)	SHIFT* (DEGREES)
1	F	50	5
2	M	32	7
3	M	25	11
4	F	28	12
5	F	35	13
6	M	65	13
7	F	26	15
8	F	56	17
9	M	8	18
10	M	65	20
11	F	24	21
12	M	15	23
13	M	20	25
14	F	22	28
15	M	27	28
16	F	15	28
17	M	21	44
18	M	27	55
19	F	1¼	64

*"Shift" represents the difference in degrees of the electrical axis of the heart as measured in the right lateral and left lateral positions.

astinitis, based on a study of five cases. The diagnosis was proved by autopsy in four, and by operation in one. It was hoped that by correlating the electrocardiographic with the pathological and operative findings the relative value of the electrical axis shift in the diagnosis of adhesive disease of the pericardium and mediastinum might be ascertained.

TECHNIC

The technic employed was that of Dieuaide. It consisted of estimations of the shift of the electrical axis from electrocardiographic tracings taken with the patient (1) in the dorsal recumbent position, (2) in the right lateral recumbent position, and (3) in the left lateral recumbent position. In some of the cases records were made in this way, then repeated in both full inspiration and full expiration.

The calculation of the electrical axis was made by the use of the graphic representation of Einthoven's formula prepared by Carter, Richter and Greene.[3]

RESULTS ON NORMAL SUBJECTS

Dieuaide estimated a normal shift of the cardiac electrical axis by inspection of the electrocardiographic tracings. No one, to our knowledge, has assigned numerical values to these axis shifts. By the use of Dieuaide's technic, a group of normal individuals varying in age from fifteen months to sixty-five years was studied. The results are tabulated in Table I, and show a normal variation of from 5 degrees to 55 degrees shift in axis.

With this wide normal range and especially with the occasional instances of 11 degrees to 13 degrees axis shift, it is obvious that fixation of electrical axis must be within the range of 5 degrees to be of any abnormal significance, which is practically within the error of electrical axis measurement.

RESULTS ON PATIENTS WITH CHRONIC ADHESIVE MEDIASTINOPERICARDITIS

The cases studied were limited to those in which proved adhesive mediastinopericarditis was present and in which the electrical axis shift was measured. A comparison could then be made with the accepted values of normal, and with the results obtained in normal, subjects by ourselves. The technic used in each case was the same.

The following brief summaries indicate the nature and extent of the pertinent anatomical findings in four patients with chronic adhesive pericarditis as revealed by operation in one case, and by autopsy in the remainder of the cases; and one case (with autopsy) of carcinomatous and inflammatory invasion of the pericardium and mediastinum.

CASE 1.—R. B., female, aged thirty-eight years. Dr. A. L. Brown removed the medial portions of the third, fourth and fifth left costal cartilages at operation (Oct. 22, 1932), and the following findings were disclosed:

The pericardium was calcified, thickened, and adherent both to the myocardium and to the anterior chest wall. The thickened pericardium could not be separated from the underlying heart muscle. The clinical and postoperative diagnoses were: chronic adhesive mediastinopericarditis, calcified, right hydrothorax, auricular fibrillation and congestive heart failure. In this case there had been an axis shift of 20 degrees on May 4, 1931, but only 9 degrees on February 15, 1934, about sixteen months after operation. (Fig. 1.)

CASE 2.—E. S., male, aged forty years. (Autopsy Nov. 27, 1932, by Dr. A. Nemir.) There were adhesions present between the right border of the pericardium and the mesial borders of the lower and middle lobes of the right lung. Adhesions were also present between the pericardium and the thoracic cage to the right and left of the sternum as well as the contiguous pleura of the left lower lobe. The pericardial cavity was obliterated by dense adhesions. The anatomical diagnoses were: chronic adhesive mediastinopericarditis; rheumatic heart disease with aortic

insufficiency, mitral insufficiency and stenosis; right bundle-branch block; pulmonary infarction and bronchopneumonia. The electrical axis shift in this case on Nov. 6, 1931, was 35 degrees.

CASE 3.—E. S., female, aged fifty-four years. (Autopsy Sept. 20, 1932, by Dr. G. Y. Rusk.) The pericardial cavity was completely obliterated by dense fibrous chronic adhesions. There were dense adhesions between the right border of the

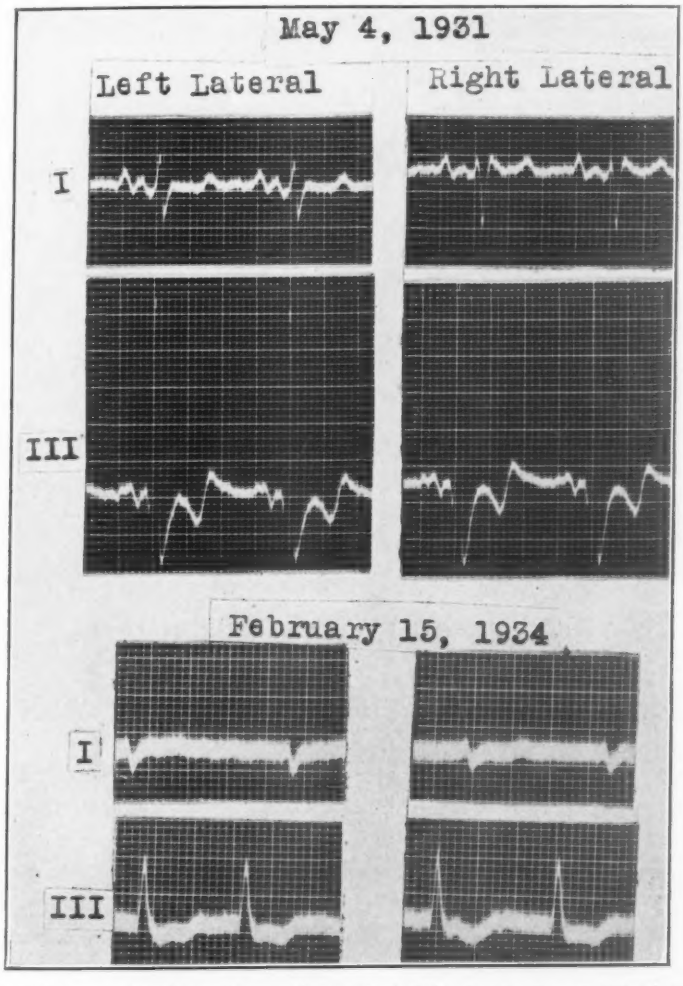

Fig. 1.—Shift in electrical axis as demonstrated by Leads I and III in the right and left lateral positions in Case 1 prior to operation and sixteen months after operation.

pericardium and the mesial borders of the middle and lower lobes of the right lung. There were also some filamentous adhesions between the pericardium and the undersurface of the rib cage. The anatomical diagnoses were: chronic adhesive obliterative mediastinopericarditis; coronary arteriosclerosis, aneurysmal dilatation of the left ventricle, cardiac hypertrophy and dilatation, anasarca, bronchopneumonia and tuberculous infection of the tracheobronchial lymph nodes.

The electrical axis of this heart on April 11, 1932, shifted 42 degrees with a change in the position of the patient. (Fig. 2.)

CASE 4.—E. B., male, thirty-three years old. (Autopsy Jan. 16, 1929, by Dr. J. F. Rhinehart.) A clinical diagnosis was made of rheumatic heart disease with adhesive mediastinopericarditis. At autopsy there was found a generalized old fibrous pericarditis partially obliterating the pericardial sac with a more recent organizing fibrinous pericarditis in the free spaces with pleuropericarditis, bilateral, and adhesions from the apex of the pericardial sac to the left anterior chest wall. There was present acute and chronic rheumatic endocarditis of the mitral and aortic valves, diffuse myocardial fibroses, multiple thrombi in the left auricular appendage and infarcts of the brain, kidney and spleen. Other incidental findings were chronic passive congestion of the abdominal viscera, bronchopneumonia, and old calcified tuberculosis of the mediastinal lymph nodes.

The electrical shift in this case on June 21, 1928, was 21 degrees.

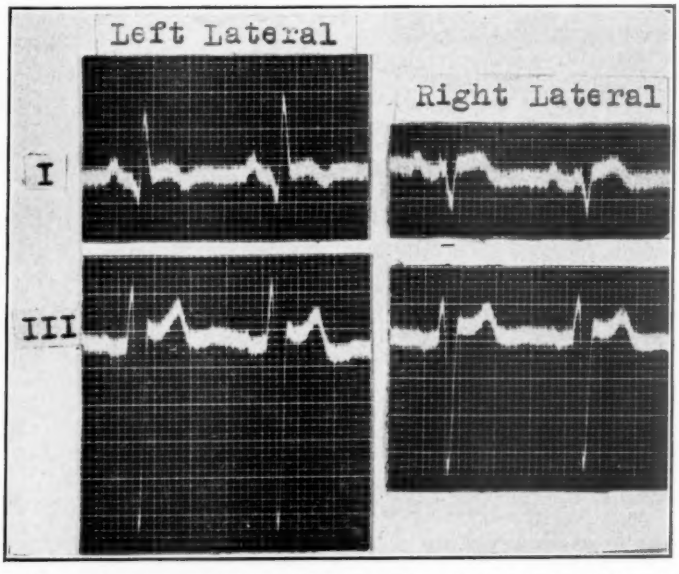

Fig. 2.—Electrocardiograms. Leads I and III demonstrating 42° electrical axis shift on postural changes (Case 3).

CASE 5.—I. B., female, aged forty-one years. (Operation by Dr. H. Brunn Sept. 7, 1927, and autopsy by Dr. G. Y. Rusk June 6, 1928.)

The history of respiratory symptoms on this patient dated from January, 1927, and the first x-ray and clinical diagnosis of carcinoma of the lung was made on July 29, 1927; and on Sept. 7, 1927, the right upper and middle lung lobes were removed. Drainage of the right pleural cavity for empyema followed, and after repeated convulsions the patient died on June 6, 1928.

The autopsy diagnosis was primary papillary adenocarcinoma of the right lung with extension into the right pleural space, the mediastinum, a portion of the right side of the diaphragm, the left lung, and the pericardium with partial obliteration of the pericardial space. There was dilatation and hypertrophy of the right auricle and right ventricle with chronic passive congestion of the abdomen, viscera and ascites and left hydrothorax. Moderate atheroma of the aortic valves, the aorta and coronary arteries and many metastases were present throughout the body. A sinus

extended through the wall of the chest into the infected pleural cavity, thence to an abscess within the mass of the tumor in the right lung.

On April 16, 1928, the electrical axis rotation on postural shift was only three degrees, well within the possible error of measurement.

DISCUSSION

An analysis of Table II shows that a normal axis rotation occurred in four of the five patients. In the one remaining case slight rotation of the axis occurred. The axis rotation in this latter case was limited to three degrees.

TABLE II

ROTATION OF THE ELECTRICAL AXIS OF THE HEART IN PATIENTS WITH FIXATION OF THE PERICARDIUM

PATIENT	SEX	AGE (YEARS)	SHIFT (DEGREES)
1. (R.B.)	F.	38	20
2. (E.B.)	M.	33	21
3. (E.Sa.)	M.	40	35
4. (E.Sc.)	F.	54	42
5. (I.B.)	F.	44	3

Each of these five patients had extreme anatomical fixation of the heart to the pericardium and of the pericardium to the anterior and central mediastinum, pleura and the chest wall. In Case 5 there was at autopsy an almost solid block of immobile carcinomatous and inflammatory tissue binding together the heart, pericardium, pleurae, right lung, and rib cage. This was the only example of genuine electrocardiographic electrical axis fixation.

The observation made by Fenichel[4] and others that the electrical axis shifted toward the right on turning the patient into the left lateral recumbent position was herein uniformly observed. This agrees with the conception that shifts of the heart in a frontal plane are more responsible for electrical axis shift than the rotation about the longitudinal axis. The heart assumes a slightly more prolonged form in the left lateral position than in the dorsal recumbent or erect position and a broader form in the right lateral position. This change in form coincides with the common occurrence of right electrical axis deviation in narrow-chested individuals and the reverse in broad-chested people, and possibly explains the nature of axis deviation in hypertrophy and dilatation of either ventricle rather than the theory of predominance of electrical potential developed by the greater muscle mass of the particular ventricle.

One may offer the hypothesis that the movement of the heart along a longitudinal axis is impeded but slightly by such adhesions as occurred in the first four cases reported. (Such motion was observed to give appreciable electrical axis shift.) The extensive involvement of the diaphragm in Case 5 may be the clue to the electrical axis fixation in that instance.

In certain other patients, clinically suspected of having adhesive mediastinopericarditis and not reported in this series because of lack of either surgical or autopsy confirmation of the lesion, electrical axis fixation on lateral rotation was observed, but there was a decided shift during respiration from the extreme positions of the diaphragm in inspiration and expiration. (Fig. 3.)

In these patients as well as in the five discussed in this report there was apparent anatomical longitudinal fixation of the heart as estimated

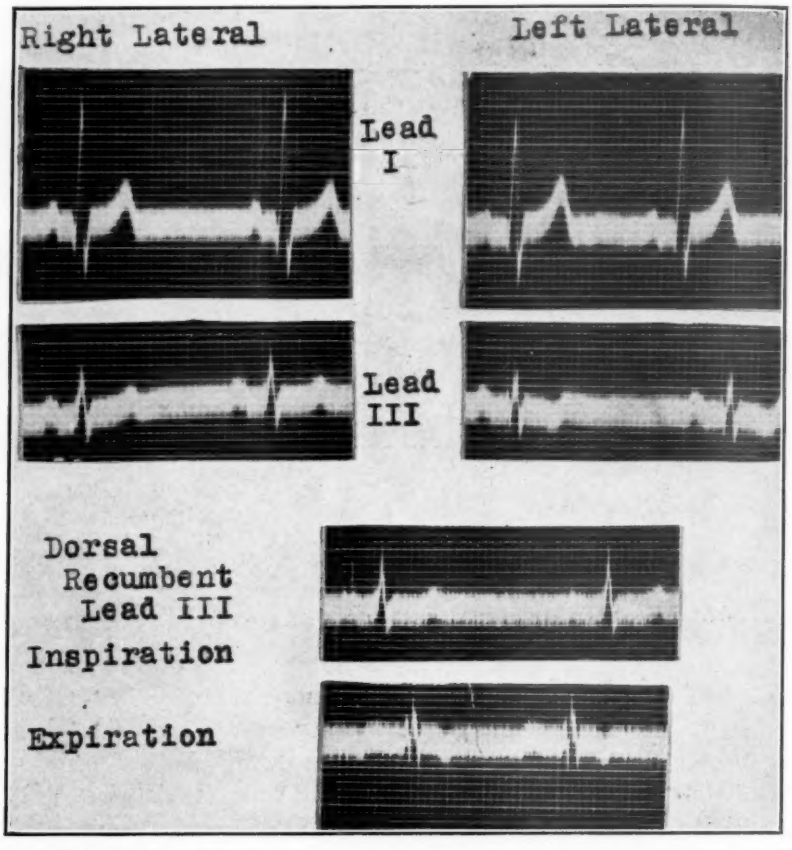

Fig. 3.—Electrocardiograms in a case of suspected adhesive mediastinopericarditis, illustrating fixation of form and electrical axis in Leads I and III on lateral posture shift, but definite difference in form of Lead III when taken in inspiration and expiration.

by constancy of position of the apex impulse, the heart border by percussion and by roentgenograms of the chest. Minor changes of the heart's position, however, are extremely difficult to estimate from roentgen ray observations. In each of the cases reported here, the position of the apex impulse of the heart as determined by palpation and percussion did not move with changes in the patient's position. This relative immobil-

ity of the cardiac apex impulse, deduced from physical examination, has served us as a far more reliable index of longitudinal axis fixation than any other means of estimate.

One may conclude from the above data that mobility of the electrical axis will not exclude extensive mediastinopericarditis but that fixation is worthy evidence of its existence probably with diaphragmatic involvement. Even this premise is not justified as a generalization, as is illustrated by the following case: a woman, aged forty-three years, (A. H.) with arteriosclerotic heart disease and hyperthyroidism with congestive failure and a large pericardial effusion showed a moderate fixation of the electrical axis (7 degrees) during acute congestive failure. Normal rotation (25 degrees) of the electrical axis of the heart was found to exist, however, following the removal of 600 c.c. of fluid from the pericardial cavity and improvement of her congestive failure.

The transient fixation in this case may have been due to the encroachment of the heart and pericardium on the other mediastinal contents and the simultaneous limitation of motion of the diaphragm by ascites and hepatomegaly.*

CONCLUSIONS

1. Normal rotation of the electrical axis of the heart may occur in patients with extensive chronic adhesive mediastinopericarditis and does not exclude the presence of this condition.

2. Fixation of the electrical axis is not pathognomonic of anatomical fixation of the heart by chronic adhesions.

3. It is suggested that when fixation does occur, the mobility of the heart has been limited in both median longitudinal and horizontal planes.

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*The influence of positions other than the right and left lateral recumbent was studied in the patient Mrs. R. B. (Case 1), and on a normal subject. The antero-posterior Lead IV of Wolferth and Wood[5] was used as well as the standard Leads I and III.

In Mrs. R. B. the degree of change in form of the electrocardiogram caused by change in the position of the body from the right to the left lateral, was less than that caused either by the change from the supine to the prone position or by the shift of the heart incident upon full inspiration and expiration without movement of the body's position. In both this patient and the normal subject the dorsal position and the right lateral and likewise the ventral and erect positions resembled one another reasonably closely in the records of Lead IV.

TRANSIENT, RECURRENT, COMPLETE BUNDLE-BRANCH BLOCK

Report of a Case*

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THE occurrence of electrocardiograms displaying complete bundle-branch block is confirmatory evidence of well-marked heart disease. There are, however, occasional exceptions to this rule. Furthermore, the electrocardiograms of complete bundle-branch block are likely to remain remarkably unaltered during the rest of the patient's existence. Exceptions to this likewise occur. Our report deals with such departures from the rule.

Few reports regarding temporary bundle-branch block are available in the literature. In 1927 Willius and Keith reported three cases of transient, incomplete bundle-branch block occurring with heart failure and disappearing with the restitution of cardiac function. Pulmonary edema coincided with the appearance of the abnormal electrocardiographic records in two cases. Baker, in 1930, reported a case of complete bundle-branch block, occurring temporarily in an elderly man, the presence of which seemed to be related to the occurrence of auricular fibrillation and to periods of tachycardia that disappeared when the heart became slowed and also during the inhalation of oxygen. More recently Morris and McGuire reported two cases of transient, complete bundle-branch block. The first occurred in a woman aged forty-six years in an attack of pulmonary edema; the second, in a woman fifty-one years of age during acute heart failure following abdominal exploration and cholecystectomy.

The mechanism evidently responsible for the development of bundle-branch block in the six previously reported cases was that involved in myocardial changes consequent to heart failure. Wolff, Parkinson, and White have observed transient bundle-branch block in apparently healthy children and in young adults who were prone to paroxysmal tachycardia. We have from time to time observed bundle-branch block as a temporary phenomenon in the course of cardiac infarction and occasionally during the combined administration of digitalis and quinidine sulphate.

In the case forming the basis of this report none of the foregoing factors was present, which adds to the interest of the phenomenon.

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REPORT OF CASE

CASE 1.—A man, aged sixty-three years, came to the Mayo Clinic because of progressive dysuria. He had been very active and energetic, he was accustomed to assuming serious responsibilities, and he was in great demand as a public speaker. He had continued to carry these burdens and considered himself still fit to resume his strenuous and varied activities. He had been unusually well throughout his lifetime, with the exception that he had had scarlet fever in childhood and influenza in the pandemic of 1918. He complained of frequency of urination, particularly at night, and thought that he was not emptying his bladder completely. In the preceding two or three years he had been slightly short of breath on undue effort; although a year prior to his admission he had ascended a high mountain and had experienced little difficulty. There had been no anginal seizures, and no evidences of congestive heart failure had been present at any time.

Examination revealed the patient to be of average stature. The peripheral arteries were moderately thickened. The heart did not appear to be enlarged, the

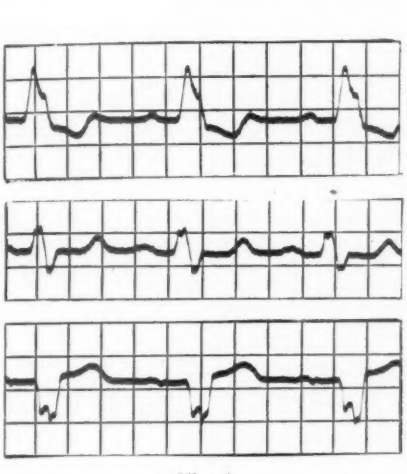

Fig. 1.

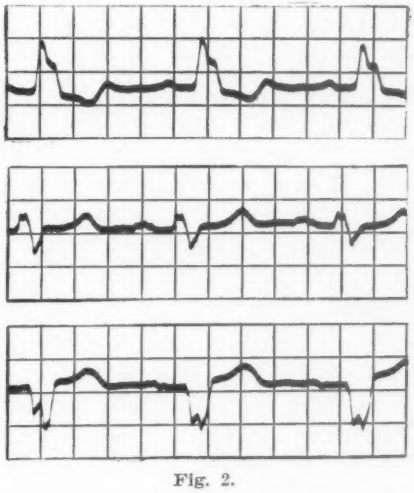

Fig. 2.

Fig. 1.—September 21. Complete left bundle-branch block; QRS intervals 0.17, 0.17, and 0.16 second. P-R interval 0.24 second.

Fig. 2.—November 13. Complete left bundle-branch block; QRS intervals 0.17, 0.17, and 0.16 second. P-R interval 0.24 second.

rhythm was regular, the tones were of good quality, no murmurs were audible, and the aortic second tone was accentuated. The prostate gland on palpation was found to be moderately, although diffusely, enlarged, and it was firm. The systolic blood pressure in millimeters of mercury ranged from 163 to 186 and the diastolic from 90 to 100. The examination otherwise revealed no important findings. Urinalysis disclosed the specific gravity to be 1.026; the urine was acid in reaction, there was no albumin or sugar present, and only a few leucocytes were found. There were 30 c.c. of residual urine. The value for hemoglobin was 14.7 mg. per 100 c.c. of blood (88 per cent Dare), erythrocytes numbered 4,500,000 and leucocytes 6,000 per cubic millimeter of blood, and the concentration of urea nitrogen fluctuated from 22 to 28 mg. per 100 c.c. of blood. Ophthalmoscopy revealed a slight degree of sclerosis of the retinal arteries of hypertensive type. A teleroentgenogram of the heart revealed no appreciable enlargement; and the electrocardiograms showed the presence of complete left bundle-branch block (new terminology). A diagnosis was

made of benign, prostatic hypertrophy, essential hypertension, and arteriosclerotic cardiac disease with complete left bundle-branch block.

Transurethral prostatic resection was performed December 19, 1933, with the patient under spinal anesthesia. There was no appreciable reaction. The patient made an uneventful recovery and was dismissed January 8, 1934.

DESCRIPTION OF ELECTROCARDIOGRAMS

The first record, obtained September 21, 1933, revealed typical, complete left bundle-branch block. The QRS intervals were 0.17, 0.17 and 0.16 second in the three

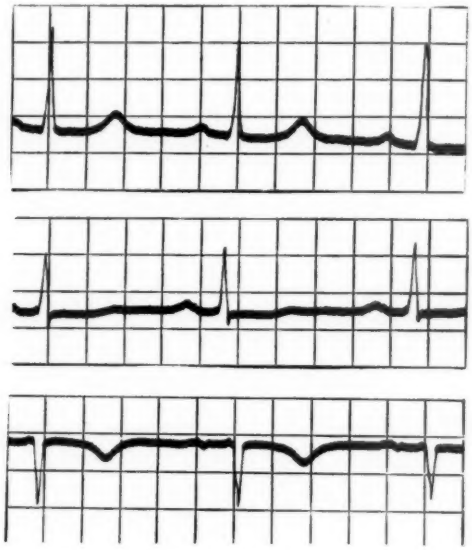

Fig. 3.—December 15. Sinus bradycardia; inverted T-wave, Lead III, prolonged S-T interval 0.38 second.

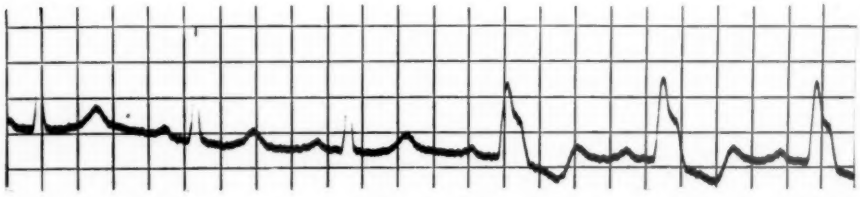

Fig. 4.—December 21. Lead I. Transition between normal rhythm and complete left bundle-branch block.

leads respectively. The ventricular components in Lead I were the mirror image of those in Lead III, and marked distortion in the contour of the QRS complexes occurred in all leads. Delayed A-V conduction also was present. The P-R interval measured 0.24 second (Fig. 1). Another electrocardiogram was taken two days later, and was identical in all respects to the one described.

It was difficult for the patient to accept the diagnosis of heart disease owing to the paucity of symptoms, and, on his return home, two electrocardiograms were taken, both of which showed the absence of bundle-branch block. This immediately raised the question of the existence of a transient abnormality, and we requested the patient to return for further observation.

He returned November 13, 1933, and the record obtained was identical with those under previous dates (Fig. 2). It then was necessary for the patient to return home, and he decided to return in a few weeks for the operative relief of the dysuria. Owing to the continued discrepancy in the electrocardiograms, he consulted still another physician at his home who made two electrocardiographic examinations; the bundle-branch block was absent on both occasions.

The patient returned to the clinic December 15, and the first tracing obtained showed the absence of bundle-branch block and delayed A-V conduction (Fig. 3). The QRS complexes were all normal in contour and time; the T-waves were inverted in Lead III and were identical mirror images of the now upright T-waves in Lead I. A prolongation of the S-T interval occurred (0.38 seconds). On the following day the bundle-branch block had reappeared. December 19 the block was absent but reappeared on the next day. December 21 we obtained an electrocardiogram showing the transition between normal conduction and complete left bundle-branch block (Fig. 4). It is interesting to observe the abruptness of these changes, occurring without intermediate configuration of the complexes. December 22 both

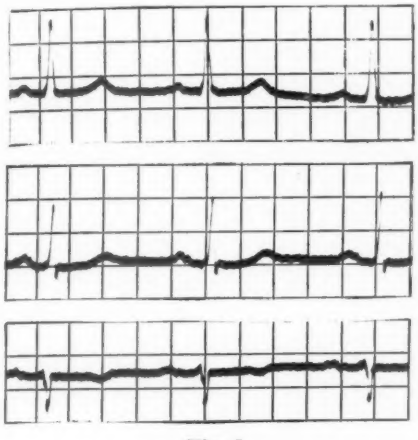

Fig. 5.

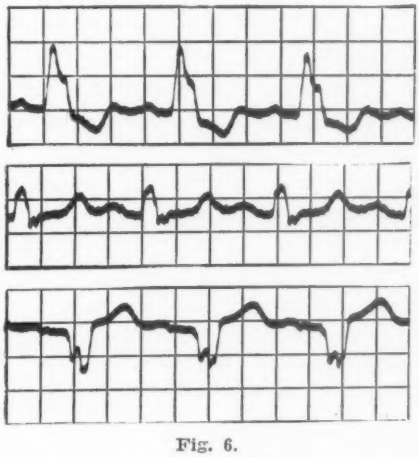

Fig. 6.

Fig. 5.—January 2, 1934. Sinus bradycardia; inverted T-wave, Lead III.
Fig. 6.—January 5. Complete left bundle-branch block; prolonged P-R interval 0.24 second.

normal and abnormal conduction occurred on two different occasions. Two records obtained December 23 revealed normal conduction. The record, January 1, 1934, showed normal conduction (Fig. 5); and the last tracing, January 5, again showed complete, left bundle-branch block and delayed A-V conduction (Fig. 6).

COMMENT

Bundle-branch block occurs most frequently, but not exclusively, with coronary disease, and the nutritional impairment thus imposed on the heart may find expression in faulty conduction. This is the presumptive explanation in this case owing to the fact that the patient's age coincides with that period of life in which coronary disease is most prevalent and to the absence of other demonstrable diseases which might have had some etiological significance.

The presence of delayed A-V conduction during the periods of bundle-branch block is interesting and indicates a rather profound and ascending interference in impulse conductivity. The fact that both bundle-branch block and delayed A-V conduction occur transiently denotes that the heart still has the ability, probably through spontaneous augmentation of its own circulation, to recover sufficiently to permit relatively normal conduction. Even though observations such as these have been made infrequently, it seems probable that transient, complete bundle-branch block is not a rare condition. It is not improbable that during the development of this abnormality periods of normal conduction may occur, and the establishment of bundle-branch block may be not abrupt but gradual; the failure in recognizing this condition as transient, complete bundle-branch block may lie in the absence of opportune electrocardiograms. This explanation also is true when applied to complete heart-block, which frequently is a transient disorder at the time of its inception.

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Department of Clinical Reports

PERICARDIAL EFFUSION FOLLOWING ACUTE CORONARY VESSEL CLOSURE*

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THE following case is of unusual interest because from a study of the literature I believe it to be the first recorded instance of pericardial effusion following an acute coronary vessel closure.

REPORT OF CASE

D. M., a Jewish male, aged fifty years, was admitted to the Montefiore Hospital on November 9, 1933. He had been perfectly well until June 10, 1933, when after a hard day's work he experienced a sharp substernal pain with radiation to the left shoulder and down to the inner side of the left arm. He took some sedative for the relief of the pain but vomited. He returned home that evening, and after two days his pain subsided somewhat, but he felt weak, perspired very freely, and suffered from marked dyspnea and gaseous eructations.

His dyspnea increased very markedly so that the only way he could obtain comfort while in bed was by sitting up with his head resting far forward on his folded arms. The patient was seen on July 7, 1933, by Ernst P. Boas, who at that time found the patient extremely dyspneic. There was dullness and marked bronchial breathing at the left base posteriorly below the angle of the scapula. The heart sounds were barely audible, and there was a to-and-fro friction rub heard best at the fourth intercostal space to the left of the sternum. In that region the heart borders percussed as far out as both anterior axillary lines. The heart rate was normal. The blood pressure was 90 systolic and 60 diastolic. A bedside roentgenogram obtained at this time (Fig. 1) revealed an unusual dilatation of the heart shadow which, in the presence of a pericardial friction rub, suggested effusion in the pericardium.

Three hundred and fifty c.c. of clear, straw-colored fluid were withdrawn from the pericardial sac with a needle inserted in the seventh intercostal space below the left shoulder blade. There was immediately very marked relief, and the patient's dyspnea disappeared gradually.

On July 26, 1933, he was admitted to Presbyterian Hospital, where a diagnosis of myocardial infarction was made. At that institution notice was taken of a bulge in the left ventricular region which was diagnosed as an intrapericardial aneurysm of the left ventricle. The character of the cardiac contour was consistent with the reaccumulation of pericardial fluid. The patient's course was prolonged by recurrences of his cardiac pain. There were several episodes suggesting fresh occlusions.

On August 21, 1933, a thoracentesis was performed with withdrawal of 350 c.c. of straw-colored fluid from the left chest. During his stay at Presbyterian Hospital

*From the Medical Division of the Montefiore Hospital, Service of Dr. Leopold Lichtwitz.

the signs of pericardial effusion finally disappeared and the electrocardiogram showed intraventricular conduction disturbance of the bundle-branch type.

On admission to the Montefiore Hospital the patient was quite comfortable. There was no dyspnea or cyanosis of the lips. The apical impulse of the heart was in the sixth intercostal space in the anterior axillary line. There was a marked disproportion between the thrusts of the heart, which were visible, and the sounds over the same region of the apex, which were very weak. Fluoroscopic and radiographic examination of the chest showed a slight increase in the central pulmonic areas. The heart shadow showed a definite bulging in the upper part of the left ventricle, the pulsations of which were slight, wavelike, and opposite in direction to those of the pulmonic conus lying just above (Fig. 2). The left ventricle showed considerable enlargement also in the oblique view, and the bulging in its upper portion was seen to be increased and gradually disappearing when the patient was rotated in the left lateral position. The pulmonary conus itself showed only slight enlargement, while the inflow tract of the right ventricle was also enlarged. The left auricle occupied a high position on the right side forming a part of the right border in the anteroposterior view. It was not enlarged.

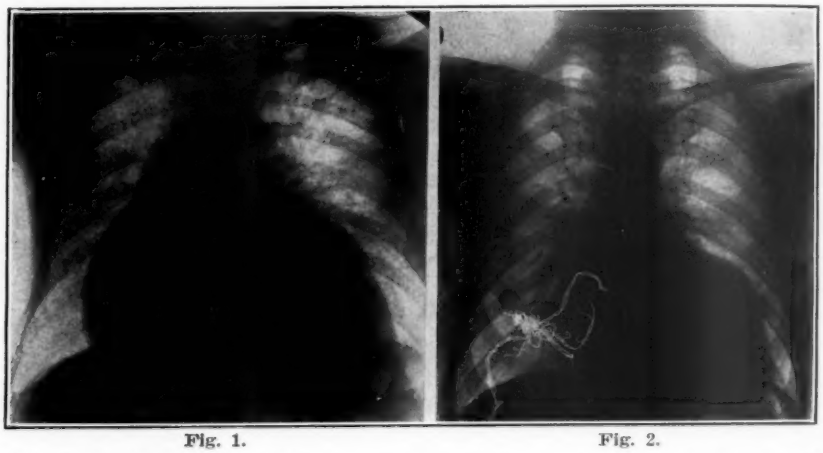

Fig. 1. Fig. 2.

Fig. 1.—Bedside plate obtained on July 7, 1933, showing effusion in the pericardium.

Fig. 2.—A comparison plate obtained on November 24, 1933, when the patient was ambulatory, showing the concentric hypertrophy of the left ventricle with a bulging aneurysm in its upper border, the result of a coronary occlusion of probably the descending branch of the left. Note the absence of pericardial effusion.

After a short period of convalescence in bed the patient was encouraged to do graduated exercises so that at the present time he is ambulatory and back at work as a photographer.

SUMMARY

A case is reported of a man, aged fifty years, who developed pericardial effusion following an acute coronary vessel closure. This diagnosis was established from both clinical and roentgenographic signs. Following paracentesis of the pericardium there was great relief in symptoms, although the fluid reaccumulated subsequently. With further rest in bed and a thoracentesis the patient became well and is at present ambulatory.

PORTAL OBSTRUCTION IN RHEUMATIC HEART DISEASE WITH ADHERENT PERICARDIUM: RUPTURE OF RETROPERITONEAL VARIX WITH FATAL HEMOPERITONEUM*

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WE ARE reporting an unusual case of rheumatic heart disease with adherent pericardium and a clinical picture of portal cirrhosis in which death occurred from rupture of a retroperitoneal varix with intraperitoneal hemorrhage. Such a complication is extremely rare even in cases of true portal cirrhosis. Bezza[1] has reported hemorrhagic pseudocyst formation of the mesentery with fatal hemoperitoneum in an individual with portal cirrhosis. Déchaume[2] described a case with fatal intraperitoneal hemorrhage as a complication of syphilitic cirrhosis of the liver.

REPORT OF CASE

F. T., a female, aged eighteen years, was admitted to the Montefiore Hospital on January 26, 1933, with dyspnea and swelling of the abdomen as her chief complaints. At the age of seven years she had had chorea. One year later, following a sore throat and tonsillitis, she had migratory joint pains. Numerous sore throats subsequently recurred, at least once a month. A heart lesion was diagnosed at the age of eleven years when weakness and pallor were observed. In September, 1929, at the age of fourteen years, dyspnea on slight exertion was experienced, and one year later signs of congestive heart failure with slight edema of the ankles appeared. She entered a hospital where the congestive failure subsided. However, recurrent bouts of congestive heart failure necessitated numerous admissions to various hospitals for the restoration of compensation. In June, 1932, swelling of the abdomen was observed for the first time with very slight edema of the ankles. The patient was admitted at that time to another institution where six paracenteses of the abdomen were performed for recurrent ascites. Her condition gradually became worse, and she was transferred to the Montefiore Hospital as a case of chronic congestive heart failure.

Examination on admission to the Montefiore Hospital revealed an extremely ill-looking young woman, orthopneic, markedly dyspneic, with cyanosis of the lips, ears, and tip of the nose. The skin and sclerae had an icteric hue. The nasal septum revealed a large perforation anteriorly. The superficial neck veins were markedly distended and showed a totally irregular ventricular type of venous pulse. The trachea was in the midline. Over the anterior chest wall and the abdomen the superficial veins were markedly dilated, prominent, and tortuous.

The apical impulse of the heart was in the left anterior axillary line at the level of the sixth intercostal space. There was marked systolic retraction in the apical

*From the Medical Division of the Montefiore Hospital, Service of Dr. Leopold Lichtwitz.

region; change of position did not affect the location of the apex. A diastolic thrill was felt at the apex where there was heard a rumbling diastolic murmur preceded by a rough systolic murmur. In the aortic region there were blowing murmurs throughout systole and diastole. The second heart sound in the pulmonic region was markedly accentuated and reduplicated. Auricular fibrillation with a rapid ventricular rate of 120 beats per minute was present. The blood pressure was 120 systolic and 40 diastolic. The peripheral vessels revealed a Corrigan pulse and pistol-shot sounds over the femoral arteries, but no capillary pulsations were noted. A few râles were heard at the base of the left lung. There was no evidence of hydrothorax.

The abdomen was markedly distended, with bulging of the flanks and protrusion of the umbilicus. White striae were prominent over the lower part of the abdomen. A definite fluid wave was present. The liver was very large, pulsatile, and extended down to the pelvic brim, 12 cm. below the right costal margin in the midclavicular line. The spleen was also markedly enlarged, its edge extending 4 cm. below the left costal margin.

In striking contrast to the marked ascites, the lower extremities revealed only slight pitting edema. The venous pressure was markedly elevated, 25 cm. of blood. The circulation time by the decholin method (antecubital vein to tongue) was markedly prolonged, 32 seconds.

There was a moderate secondary anemia with a hemoglobin count of 60 per cent (Sahli). The erythrocytes numbered 3,500,000 per cubic millimeter. The leucocyte count and differential smear were normal. The blood Wassermann reaction and the Kahn precipitin test were negative. The blood serum albumin was 3.50 and the serum globulin 1.72 grams per 100 cubic centimeters of blood.

X-ray and fluoroscopic examinations of the chest revealed marked enlargement of the left ventricle and of the left auricle, part of the left auricle appearing on the right border of the heart when viewed in the anteroposterior position. There was moderate enlargement of both the inflow and the outflow tracts of the right ventricle. No definite enlargement of the right auricle could be demonstrated. Several areas of infiltration in the right infraclavicular region and one in the right mid-zone region were interpreted as indicative of pulmonary infarctions. The central pulmonic vessels were very prominent.

The electrocardiogram showed auricular fibrillation with right axis deviation.

Course in the hospital: During her stay in the hospital the patient became progressively worse. She required paracenteses of the abdomen from one to three weeks apart, each one yielding 5 to 12.5 liters of fluid. Cultures of the abdominal fluid were repeatedly sterile. Despite the massive ascites, edema of the legs was always minimal. During the first two months in the hospital her temperature was normal, aside from an occasional transitory rise to 101° F. Thereafter, however, a low grade fever persisted with rises up to 101° F., for which no adequate explanation could be found aside from the assumption that rheumatic activity was present. Occasionally a hacking cough was noted, but no expectoration was produced. Four months after admission the temperature gradually rose to 103° F., and thereafter varied from 99° to 103.2° F. A blood culture obtained during this period was negative.

In the middle of May, 1933, she developed mild diffuse abdominal pains following the removal of nearly 11 liters of ascitic fluid at one time. Marked diffuse abdominal tenderness was elicited, but there was no rigidity. The pains persisted, the umbilicus became red, and an exploratory puncture of the abdomen yielded a homogeneously bloody fluid, culture of which was sterile. Because of the numerous varices in the abdominal wall, it was suspected that one of these veins had accidentally been

punctured during the last paracentesis. Her abdominal symptoms gradually disappeared. Two weeks later, on June 2, 1933, the patient suddenly died while asleep.

Necropsy.—(Only the important findings will be detailed.) The peritoneal cavity contained 2 liters of homogeneously bloody fluid. A large hematoma, 7 to 8 cm. in diameter, was found in the lateral wall of the right side of the abdomen just beneath the parietal peritoneum. It overlay a very markedly distended and partially thrombosed vein which had ruptured. The hematoma had ruptured into the peritoneal cavity at one point. The veins on the inner surface of the abdominal wall and those in the retroperitoneal region were distended and tortuous.

The heart was very large, weighing 1,100 gm. The pericardial sac was completely obliterated, and the inferior vena cava was partially constricted and embarrassed by adhesions as it entered the pericardial sac. Dense adhesions to the diaphragm were present. Microscopic examination revealed marked thickening with vascular fibrous tissue. The left ventricular wall measured 19 mm. and the right ventricular wall 6 mm. The myocardium revealed marked hypertrophy of the muscle fibers with numerous scars throughout, some deeply hyalinized. All the chambers of the heart were markedly distended. The aortic valve showed rolling and shortening of the anterior and mesial leaflets with slight fusion of their commissures. The mitral valve was only slightly thickened along the line of closure in the lateral leaflet. The chordae tendineae were somewhat shortened and the papillary muscles considerably hypertrophied. Although the left auricle and pulmonary veins were enormously distended, the pulmonic conus was about normal in size. The tricuspid valve was slightly thickened and the lateral leaflet somewhat rolled. The papillary muscles were hypertrophied. The valvular measurements were: aortic ring 7.5, mitral ring 15.5, pulmonic ring 7, and tricuspid ring 16 cm.

The right lung presented a few adhesions over the lateral portion of the upper lobe. A deep irregular scar in the lower portion of this lobe was apparently the residuum of an old infarct. A triangular wedge-shaped area of consolidation extended from the hilum to the periphery of the upper lobe. Throughout this area numerous small tubercles and several larger caseous nodules were observed, with little evidence of fibrosis. At the hilum and in the lower lobe several sharply defined, caseous nodules were noted. Microscopic sections revealed an extensive tuberculous pneumonic process in the consolidated region; typical tubercles and areas of caseation were seen. The left lung was markedly edematous but there was no evidence of tuberculosis.

The liver was massive and firm, weighing 2,200 gm. The hepatic venous radicles were markedly distended. The portal and splenic veins were patent and distended. The portal vein appeared to be kinked at the hilus of the liver. The capsule of the liver was thickened irregularly and presented fibrinous deposits. On section the liver was nutmeg in appearance. Microscopically the picture was that of extensive chronic passive congestion compressing the surrounding liver tissue, with some central fibrosis and atrophy and moderate fatty changes. In some areas there was connective tissue replacement within the central portions of the lobules.

The spleen was moderately soft, weighed 550 gm. and revealed the histological picture of marked chronic passive congestion.

COMMENT

Our case presents the unusual feature of clinical portal obstruction associated with fatal intraperitoneal hemorrhage from a ruptured abdominal varix. On clinical and pathological examination there was a healed pancarditis, the etiology of which was probably rheumatic.

While active tuberculosis of the right upper lobe of recent origin was present, the findings lead us to believe that this condition had no causative relation to the adhesive pericarditis and to the condition simulating portal cirrhosis.

A clinical picture of cirrhosis of the liver and negative findings at necropsy is not uncommon in adherent pericardium, whether due to tuberculosis or to rheumatic heart disease. Friedl Pick[3] and R. C. Cabot[4] many years ago called attention to cases of long-standing pericarditis with a clinical picture of portal cirrhosis. The course was one of dyspnea, large liver, and recurrent ascites requiring repeated paracenteses, with only slight edema of the legs. At necropsy only an adherent pericardium and nutmeg liver were found. There was no evidence of portal cirrhosis histologically.

The mechanism by which chronic congestive heart failure due to adherent pericardium produced a picture of portal obstruction in our case warrants further comment. Marked chronic passive congestion of the liver occurs as a rule with increased venous pressure in the hepatic veins and failure of hepatic venous compensation in cases of (1) increased pulmonary vascular pressure following rheumatic heart disease with mitral stenosis, or long-standing hypertension and coronary artery disease, (2) extensive fibrotic pulmonary lesions or emphysema with narrowing or obliteration of a great part of the pulmonary vascular bed, (3) tricuspid valvular lesions, (4) constriction by pericardial adhesions of the inferior vena cava as it enters the pericardium, and (5) thrombosis of the hepatic veins. In long-standing congestive heart failure, dilatation of the hepatic veins is common. In tricuspid disease particularly the intrahepatic venous pressure may be enormously increased, and it is with this lesion that so-called "cardiac cirrhosis" and ascites are most commonly associated. In like manner constriction of the inferior vena cava by pericardial adhesions would throw an even greater burden on the hepatic and central veins with resultant markedly increased venous pressure in this region. According to Moschkowitz[5] the long-standing increased venous pressure in the liver leads to phlebosclerosis of the central and hepatic veins. Connective tissue is deposited in the capillaries around the central veins. This in turn throws an additional burden on the portal venous system with, eventually, the production of ascites. Thus the mechanism is essentially that of the portal obstruction caused by portal cirrhosis. Another significant factor in our case may have been the kinking of the portal vein near the hilus of the liver, although the portal vein and its tributaries were patent.

Rohde[6] calls attention to the activity of the diaphragm and its effect in aiding the flow of venous blood from the hepatic veins and inferior vena cava into the right auricle. He points out that adherent pericardium may hinder the activity of the diaphragm and thus be

another factor producing congestion in the inferior vena cava and the hepatic veins. Of great significance is the experimental work of Rehn,[7] who produced varying degrees of narrowing of the inferior vena cava. Stasis in the region of the inferior vena cava resulted. The caval stenosis hindered the flow of blood to the heart and produced insufficiency of the right auricle due to inflow stasis. As a result of the congestion, degenerative processes in the liver parenchyma set in with, eventually, proliferation of connective tissue in the walls of the central and sublobular veins and obliteration of their lumina. In every case, increased peritoneal fluid resulted. No edema of the legs was observed. The azygos vein became dilated, but no hydrothorax was noted.

In our case the extensive pericardial adhesions to the diaphragm probably played a contributory rôle to that of the constriction of the inferior vena cava by pericardial adhesions, embarrassing the circulatory dynamics of the hepatic venous system and producing the clinical picture of portal obstruction.

SUMMARY

1. A case of healed rheumatic heart disease with adherent pericardium and a clinical picture of portal obstruction is reported. Death occurred from a ruptured retroperitoneal varix with hemoperitoneum. Active pulmonary tuberculosis was an incidental finding at necropsy.

2. The mechanism of so-called "cardiac cirrhosis" and its relation to the production of a picture of portal obstruction are discussed.

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ELECTROCARDIOGRAPHIC EVIDENCE OF RECENT CORONARY THROMBOSIS SUPERIMPOSED ON BUNDLE-BRANCH BLOCK RESULTING FROM PREVIOUS CORONARY DISEASE

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LITTLE has been noted or written about electrocardiographic evidence of recent coronary thrombosis superimposed on electrocardiographic evidence of previous coronary disease. Therefore it is of interest and importance that I present a clear instance of such evidence with post-mortem examination. Here a change in the T-waves (Fig. 1) was discovered a few weeks after a late coronary thrombosis superimposed upon antecedent bundle-branch block which accompanied a history of ten years of angina pectoris and of an earlier coronary thrombosis; the first myocardial infarction preceded the second by three years. I have discovered no report of this finding in the literature, nor other examples in the electrocardiographic file of the Massachusetts General Hospital.

CASE REPORT

R. A. F., male, architect, first consulted me on November 8, 1929, at the age of sixty-one years, seven years after the onset of angina pectoris on effort (high substernal oppression lasting a few minutes at a time) and five months after an attack of coronary thrombosis which occurred during a trip to the Pacific Coast. For the first three years of the angina pectoris he was not much troubled by it; then it increased in frequency and severity, and after two more years, that is, in 1927, it was associated with aching in the right arm and came with excitement and nervousness as well as on exertion. In 1928 nitroglycerin was prescribed, and this drug quickly relieved the individual attacks.

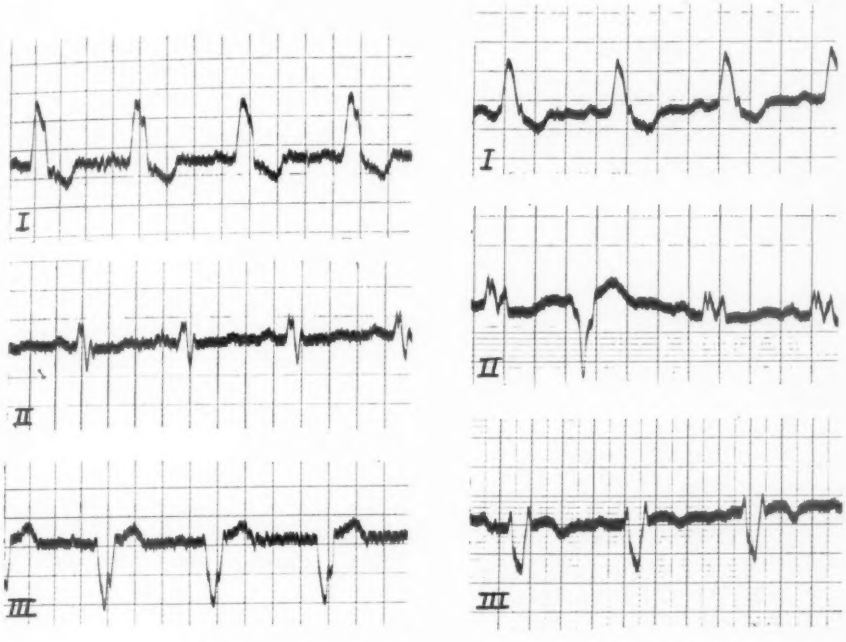
His *past history* gave a record of measles, mumps, and chickenpox in childhood, typhoid fever and pneumonia at about forty years of age, a nervous breakdown at forty-nine years, herpes zoster at fifty-eight years, and renal calculus with passing of the stone in Los Angeles in the summer of 1929.

His *habits* were good. He used little tobacco, tea or coffee, and alcohol moderately. He took regular exercise.

His *family history* disclosed the fact that his father had had angina pectoris for many years (estimated at twenty-five by the patient) before his death at the age of eighty years. His mother lived to be seventy-eight years old. A grandfather died at ninety-eight years. One brother and two sisters were alive, all troubled with "heart disease." Another sister had arthritis, and two other sisters died in youth.

Physical examination by myself on November 8, 1929, revealed a tall, well-developed and nourished man, deeply tanned and apparently the picture of health.

His breathing was normal. The pupils were equal and reacted normally to light. There was a slight arcus senilis in both eyes. The thyroid gland was not enlarged. The teeth were mostly false. The tonsils were small. There was no abnormal pulse in the neck, either arterial or venous. The heart was somewhat enlarged, with apex impulse and left border of dullness at the sixth rib, 10 cm. to the left of the midsternal line and just beyond the midclavicular line. There was no abnormal dullness at the base of the heart or to the right of the sternum. The heart sounds were rather poor in quality, and there was a slight protodiastolic gallop rhythm at the apex. There were no murmurs or thrills. Occasional premature beats were heard. The pulse was normal in form and the radial arteries were soft. The lungs were clear and the abdomen was normal. There was no edema over the shins. The



A. *B.*

Fig. 1.—Electrocardiograms (Leads I, II and III) of patient R. A. F., first (Aug. 17, 1931), following nine years of angina pectoris and two years after a first coronary thrombosis (*A*); and second (Sept. 16, 1932), seven weeks after a second coronary thrombosis (*B*). Time = 0.2 second. Amplitude: 1 mm. = 10^{-4} volt.

Bundle-branch block with left axis deviation is evident in both records, but in the second there has developed a change in the T-wave, especially in Lead III and slight changes in the QRS-wave, most evident in Lead II.

knee jerks were normal. The pulse rate was 84 and the blood pressure was 165 mm. mercury systolic and 100 mm. diastolic with slight alternation (5 mm.).

Electrocardiograms Nov. 8, 1929, Aug. 26 and Nov. 24, 1930, May 19, Aug. 17, and Nov. 23, 1931, and Feb. 29, 1932, showed bundle-branch block with left axis deviation (Fig. 1 *A*) and ventricular premature beats in the 1929 record. On May 26, 1930, the bundle-branch block was temporarily absent; the electrocardiogram on that day showed normal rhythm at a heart rate of 70 with marked left axis deviation but narrow QRS waves within normal limits of duration and low but upright T-waves throughout.

Course of Illness. During the next three years and until his death I examined this man at intervals of three to six months. For these examinations he was able to come to my office except in the summer of 1932, when I saw him at home during his acute illness with coronary thrombosis.

Through the spring and summer of 1930 he improved considerably, having only occasionally a little angina pectoris if he hurried when carrying a bundle or if he became angry. He required only about 8 tablets of nitroglycerin a month. The only other medication was the use of metaphyllin or theominal at times. If he did not hurry, he was able to do a good deal without discomfort: he was busy in his work, frequently walked several miles a day, often swam, and even climbed six flights of stairs at a time. In May, 1930, not only did he show much subjective improvement, but his gallop rhythm, pulsus alternans, and even his bundle-branch block were no longer present. His blood pressure averaged about 150 mm. systolic and 90 mm. diastolic. In the winter of 1930-1931 he was not quite so well but nevertheless quite active and in a fair state of health. His bundle-branch block had returned. In the spring and summer of 1931 he again gained in health and could go sometimes for a week without requiring nitroglycerin. Through the next fall and winter he was not quite so well, cold weather and business worries apparently being responsible.

On July 23, 1932, he suffered an attack of severe substernal pain radiating down both arms and lasting altogether about eighteen hours. Morphine and codeine gave partial relief. Fever and dyspneic spells followed for a few days, and on July 27 when I saw him he showed some orthopnea, a return of his protodiastolic gallop rhythm at the cardiac apex, a reduced blood pressure (110 mm. systolic, 80 mm. diastolic), moderate engorgement of the neck veins, and slight enlargement of the liver. After digitalization and prolonged rest in bed he improved greatly and on September 16 he was able to come convalescent to my office. At that time his physical examination showed much the same findings as before the recent attack of coronary thrombosis, and there was no sign or symptom of congestive failure. Angina pectoris had returned.

On this date, September 16, 1932, his electrocardiogram was of considerable interest, showing as it did not only the bundle-branch block, as before, but a change in the T-waves, especially in Lead III (Fig. 1 *B*), undoubtedly the result of the new myocardial damage. There was also a slight change in the QRS waves. One ventricular premature beat was recorded in Lead II.

In October, 1932, acute congestive failure came on after undue exertion, and following a week of orthopnea and progressive failure the patient died (October 10, 1932).

Post-mortem examination showed a very large heart, weighing 800 grams, with hypertrophy and dilatation of both ventricles. The left ventricular wall measured 18 mm. in thickness except at an area of considerable thinning 2½ cm. in diameter in the anterior wall 2 cm. from the apex and 1 cm. from the interventricular sulcus; the right ventricular wall was 8 mm. thick. Adjacent to the old scar in the anterior wall of the left ventricle at the point of thinning mentioned above there was evident softening and necrosis of the muscle in two areas—one to the left and near the apex 3 by 2 cm. in diameter and the other at the junction of the anterior wall and the interventricular septum. Overlying these two areas on the endocardium were two partly organized ante-mortem mural thrombi. There was a small firm scar in the myocardium of the left auricle near the tip of the appendage.

Coronaries: On dissection the anterior descending branch of the left coronary artery was found to bifurcate into two branches at a point 4 cm. below the main left coronary division. Continuing distally one of these branches coursed a trifle to the

left of the interventricular septum. This branch was found to be completely occluded for a distance of 2 cm. by a calcification of its wall. The second branch coursed distally toward the apex of the heart in a region about midway between the left blunt border and the interventricular septum. This vessel was found to be occluded by a definite grayish red thrombus 2.5 cm. from the point of bifurcation. These two vessels were split in a Y-shaped manner to enclose the dimpled area on the surface of the ventricle. The right coronary showed marked arteriosclerotic changes with slight diminution in the lumen, but at no place was it completely occluded. The left circumflex coronary branch was comparatively free from arteriosclerotic changes. The orifices of both the right and the left coronaries were completely surrounded by atheromatous plaques, and their mouths were diminished in size, measuring approximately 3 mm. in diameter. The ascending thoracic aorta was somewhat atheromatous but showed very little calcification. The valves showed no abnormalities except for slight atherosclerosis.

SUMMARY

A case is reported of electrocardiographic evidence of recent coronary thrombosis, chiefly a change in the T-wave of Lead III consisting of a late inversion, superimposed on bundle-branch block from previous coronary disease in a man who died at the age of sixty-four years, ten years after the onset of angina pectoris, three years after his first coronary thrombosis, and three months after his second coronary thrombosis. The bundle-branch block was found a few months after the first myocardial infarction, and the new T-wave change a few weeks after the second.

CALCIFICATION OF THE MYOCARDIUM FOLLOWING CORONARY OCCLUSION

A Case Report

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DIAMOND[1] in reviewing the literature on myocardial calcification discovered forty-four recorded instances.

These cases were divided into three groups, due respectively to vascular disease in the heart, to some infection, or to toxic causes. The condition follows necrosis or certain forms of degeneration, excepting fatty degeneration. Of those due to vascular disease the first instance of myocardial calcification obviously due to coronary disease was reported in 1768 by Bordenave.[2] Ten others due to vascular disease in the heart muscle have been reported since. That described by Scholz[3] most nearly approximates the findings as appended in this case report.

CASE HISTORY

Patient A. L., aged sixty years, male, laborer, first seen July 12, 1933, by Dr. K. W. Emanuel of Duluth.

Present Complaint: Numbness of the left foot.

History of Present Illness: The patient stated that the present illness began June 23, 1933, when he contracted what he thought was the "flu." He had a nasal discharge with some sneezing, felt tired, and had general aches and pains throughout his body. On July 5, 1933, he saw a physician, who advised him to go to bed and who told him he had heart trouble. The specific data of the diagnosis, however, are wanting. On July 11, 1933, his left large toe suddenly became cold, and within half an hour this numb and cold sensation had extended as far as his knee. He entered the hospital on July 12. On inquiry it was found that the patient had always felt well except for some slight dyspnea on exertion which he had observed occasionally for several years.

Past Medical History: In 1916 the patient was told that he had heart trouble, although he never had any symptoms that appeared to be referable to his heart. However, he was sick in bed for two weeks at that time and was thought to have influenza. This history might have some bearing on the autopsy findings in this case, and may have indicated a disability incident to a coronary occlusion.

Social History: Married, no children. Denies ever having had any venereal disease. Family history negative.

Physical Examination: The patient was well developed and nourished and appeared to be about sixty years of age. Color and strength appeared normal. Mental cooperation was excellent.

The examination of the head and neck, including special sense organs, was negative except for several carious teeth.

The examination of the chest indicated a moderate enlargement of the heart and an irregular rhythm probably due to an auricular fibrillation, but gave no other abnormal evidences. The lungs were negative.

The pulse rate was 100 per minute and irregular. The blood pressure was 133/90.

Extremities: The left foot and leg up to a point below the left knee were cold, bluish in color and mottled. The knee reflexes were absent on the left side, and there was an inability to move the left foot or ankle. Sensation was absent in the left foot and leg to a point 1 inch below the knee.

A diagnosis was made of gangrene of the left leg, probably associated with his myocardial insufficiency and auricular fibrillation. The obstruction to the circulation was probably due to an arterial embolus incident to intramural cardiac thrombi.

On July 14, 1933, the left leg was amputated below the knee by Dr. E. E. Webber, and the immediate postoperative convalescence was characterized by no adverse developments.

The gangrene appeared to continue up the left thigh, and on July 23 it was found necessary to disarticulate the left leg at the hip. It was found that all the large vessels, arterial and venous, were thrombosed. The patient's condition remained good, and his wound healed satisfactorily.

On September 11, 1933, the patient became stuporous and developed a paralysis of the entire left side of the body. He finally lapsed into coma, and died September 16, 1933.

The diagnosis of the condition immediately preceding his death was that of a cerebral embolism in the right hemisphere.

Autopsy Findings: Upon opening the thoracic cavity there were extensive and tough fibrous adhesions over the left upper lobe and between the lower lobe, left, and the diaphragm. The right lung showed a few fibrous adhesions to the diaphragm. Upon opening the pericardium the anterior surface of the left ventricle was found attached by tough fibrous adhesions to the anterior wall of the pericardial sac. The adherent part of the left ventricle showed extensive calcification. The heart contained some clotted blood and the left ventricle small masses of mural thrombi. The anterior part of the left ventricle bulged forward, quite thin and densely calcified in an area measuring about 7.5 by 6.5 cm. This area, which was quite rigid, had the shape of half of the shell of an egg, its concavity forming part of the internal surface of the left ventricular septum. The left ventricle and the left auricle were somewhat dilated. The mitral valves showed a very cloudy yellowish area, the aortic valves slightly thickened and sufficient. The coronary arteries showed marked arteriosclerotic changes, and the anterior descending branch of the left coronary was partly obliterated. The heart weighed 480 gm. The left lung weighed 600 gm., the right lung 500 gm. Both apices showed fibrous areas. Both lungs revealed areas of bronchopneumonia in their posterior and lower parts. There was a small embolus in the left lower branch of the pulmonary artery and a large embolus in the main branch of the right pulmonary artery. In the right lower lobe was a large hemorrhagic infarct. The bronchi were somewhat diffusely dilated and contained much seromucous purulent material. Their mucosa was quite congested. The hilus glands showed nothing of note.

The spleen weighed 130 gm., with several old and more recent anemic infarcts. The adrenals indicated nothing of note. The capsule of the kidneys was adherent in places. The kidneys weighed 280 gm. and showed several old and more recent anemic infarcts. The liver weighed 1,330 gm. and showed marked chronic congestion. The remaining abdominal organs showed nothing

of importance. The left external iliac artery was thrombosed up to the point of bifurcation of the left common iliac artery. The left iliac vein was thrombosed. The aorta showed arteriosclerosis Grade II.

Upon opening the skull, the dura was somewhat adherent to the internal surface of the skull. The internal surface of the dura was smooth. The sinuses of the dura contained partly clotted blood. The convolutions of the brain were somewhat flattened, and there was but little subarachnoidal fluid. The arteries of the base of the brain showed a few quite small yellowish spots. The right middle cerebral artery was closed by a small embolus and a massive thrombus. The ventricles of the brain contained some slightly bloody fluid. There was a large area of softening of the right cerebral hemisphere, involving mainly the right temporal lobe and extending to the lenticular nucleus and the internal

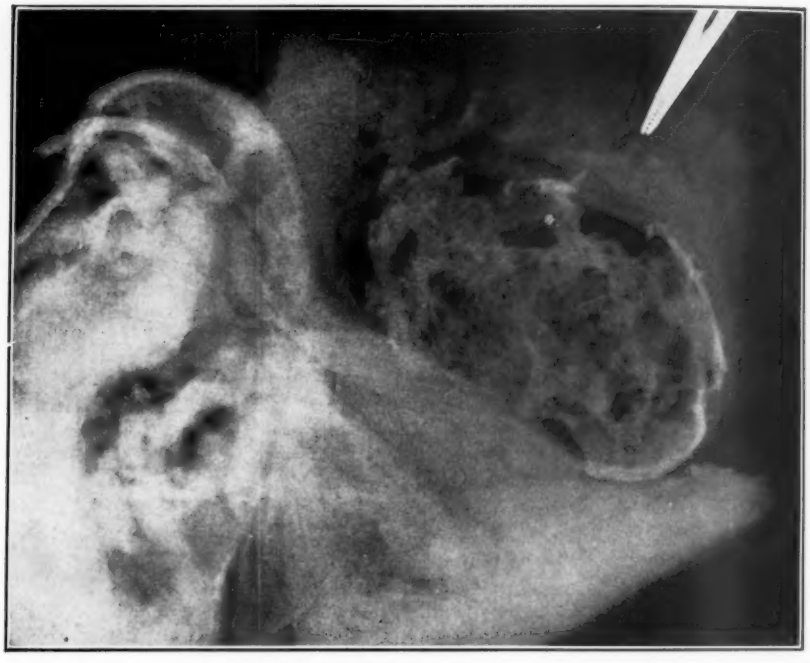

Fig. 1.—Roentgenogram of heart taken post mortem, illustrating plaque calcification of left ventricle.

capsule. The left cerebellar hemisphere showed also a large area of softening which involved about four-fifths of the lobe.

The roentgenogram shown in Fig. 1 indicates clearly the degree of density and the extent of the calcified plaque in the left ventricle.

Microscopic Examination.—Sections have been made after decalcification through the densely calcified areas of the wall of the left ventricle. Those areas are formed by masses of fibrous connective tissue with only a few cellular elements. In the calcified areas the nuclei cannot be recognized. The tissue is hyaline and densely infiltrated with lime salts. A few bundles of muscle fibers which are embedded in the fibrous areas surrounding the calcified parts are atrophied and show a definite increase of the interstitial connective tissue. In some areas the tissue is infiltrated with a few scattered lymphatic cells.

SUMMARY

An instance of myocardial calcification subsequent to coronary occlusion is reported in which the plaquelike calcification involves the area of the heart muscle supplied normally by the occluded descending branch of the left coronary artery.

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Society Transactions

NEW YORK COMMITTEE ON CARDIAC CLINICS, 1934

THE annual scientific meeting of the New York Committee on Cardiac Clinics was held in New York City on April 24, 1934, with Doctor J. Hamilton Crawford as presiding officer.

The following are abstracts of papers presented or read by title:

Fibers of the Purkinje System in the Walls of the Mammalian Ventricle. David I. Abramson, M.D.

ABSTRACT

It is generally considered that the impulse in the heart, after spreading over the subendocardial Purkinje system, leaves this network to extend throughout the ventricular musculature by virtue of the conductivity of the myocardium itself. However, a study of beef, sheep and pig hearts by means of the injection method shows that these hearts contain, besides the subendocardial Purkinje network, another set of Purkinje fibers which penetrates the ventricular musculature. These myocardial fibers extend practically throughout the outer walls of both ventricles, reaching in many sites as far as the epicardium. They form plexuses and ramifications similar to the subendocardial network, of which they are a continuation. In the outer wall of the left ventricle these myocardial plexuses are disposed in layers which extend roughly perpendicular to the subendocardial network; whereas in the outer wall of the right, the layers are nearly parallel to the subendocardial network and to one another. In the interventricular septum, myocardial Purkinje fibers are also present, connecting the subendocardial network of the right ventricle with that of the left. Employing special staining methods, histological studies were made which confirmed the results obtained by injection and also demonstrated that in structure and staining properties these myocardial fibers are similar to the subendocardial Purkinje plexus.

Growth of the Cardiac Silhouette and the Thoraco-abdominal Cavity During Infancy. The Influence of Undernutrition. Harry Bakwin and Ruth Morris Bakwin.

ABSTRACT

At birth the cardiac silhouette lies anterior to the fifth to the tenth dorsal vertebrae. It is globular and more centrally placed than it is later in life. The left cardiac outline is ordinarily convex and only rarely shows the divisions seen in later life. During the first year the heart grows rapidly, the frontal plane doubling its area. At the end of the first year the heart silhouette is less horizontal than at birth. The left border often shows the divisions seen in later life, at times very prominently. Averages and standard deviations for the dimensions by certain subdivisions of age under one year were calculated. The transverse diameter of the cardiac silhouette is poorly correlated with total body length, body weight, sitting height, biacromial diameter, bimalar diameter. There is a low correlation with the thoracic width, measured roentgenologically. The growth in size and shape of the cardiac silhouette in the healthy group was compared with that in a group of undernourished infants. In the latter the cardiac silhouette grows more slowly than in

healthy infants. The retardation in growth of the heart is greater than that of total body length or thoracic width so that the heart becomes smaller, relative to total body length and to thoracic width, than is the case in normal infants.

Results of Intensive Ambulatory Treatment of Advanced Cardiac Insufficiency. Meyer Friedenson, M.D.

ABSTRACT

Ambulatory treatment was applied to cases of advanced cardiac insufficiency over a period of several years. These individuals had hitherto required numerous hospital admissions. We were guided chiefly by the weight, degree of dyspnea, and ventricular rate. The chief problem was the control of fluid accumulation. Treatment consisted mainly of intensive use of diuretic measures. Fluid and salt intake was restricted by calculated diets. "Maintenance diuretics," urea or ammonium nitrate, were given constantly to help prevent fluid reaccumulation. Frequent injections of salyrgan were used when rapid action was necessary. Digitalis and other drugs were administered when indicated. Through special arrangement the patient was treated at home if temporarily unable to attend the clinic. The fact that the patients can remain at home is of distinct psychological importance. It is not claimed that improvement thus obtained renders the patients less liable to sudden death. Whether life has actually been prolonged, we cannot say. There is no doubt, however, that existence is made much more tolerable. Intensive ambulatory treatment with diuretic measures affords considerable relief for prolonged periods to many patients who do not respond to the usual methods.

The Effect of Edema on the Amplitude of the Electrocardiographic Waves. Morris Goodman, M.D.

ABSTRACT

The object of this study was to determine whether edema is a factor in the production of low amplitude of the electrocardiographic waves of patients who have advanced heart disease. (1) Three dogs were made markedly edematous by the method of plasmaphoresis. Electrocardiograms were taken before, during, and after edema. The amplitude of the waves of Leads II and III in each instance fell to about one-third the original height. The waves of Lead I remained unchanged or fell slightly. When the edema disappeared, the amplitudes increased. (2) In seven animals localized edema was produced about the chest by infiltrating saline under the skin of that area. Electrocardiograms were taken before, during, and after infiltration was absorbed. The results were similar to those observed when generalized edema was produced. (3) In four animals 1,000 c.c. of saline were infiltrated into the thighs. In no instance was a fall in amplitude of the electrocardiographic waves produced. (4) In six patients 1,000 c.c. of saline were infiltrated into the chest wall. The amplitude of the electrocardiographic waves showed little or no effect when conventional leads were used but showed a consistent fall with chest leads. Electrocardiograms of 27 patients were studied. These patients while under care lost a minimum of 6 kilograms of weight, representing edema fluid. Only 5 showed a consistent increase in amplitude as the edema disappeared. The increase to maximum amplitude occurred before all the edema disappeared. The loss of weight in this group was in excess of 12 kilograms. There were others with an equal loss of weight who showed no change. Conclusions: (1) Edema fluid in the tissue close to the heart causes a decrease in the amplitude of the electrocardiogaphic waves when the edema is of large and sufficient quantity. If the edema is localized, it will decrease the amplitude of the waves obtained by leading off from the site of edematous tissue. (2) The edema need not be in the cardiac musculature. (3)

The amount of edema generally seen in patients with congestive heart failure has little or no effect on the amplitude of the electrocardiographic waves because it is rare to have it distributed to as high a level as the chest wall.

Studies on the Myocardial Aschoff Body. Louis Gross, M.D., and Joseph C. Ehrlich., M.D.

ABSTRACT

The clinical histories and anatomical material from seventy cases of uncomplicated rheumatic fever with Aschoff bodies in the myocardium were investigated. A histological classification of the Aschoff body is suggested. This classification includes seven types of lesions which apparently bear some relation to the life cycles of the Aschoff body. It is shown that these lesions pass through three phases. The earliest phases have been found to occur up to the fourth week after the onset of the illness; the middle phases, between the fourth and thirteenth week, and the late phases from the ninth to the sixteenth week. The earliest types of specific lesions occur in two forms. As a consequence, the evolution of the lesions may take one of two courses, determined by the initial lesion.

Some Observations Concerning the Use of Mercurials in Heart Disease. Robert H. Halsey, M.D.

ABSTRACT

When the edema and anasarca of heart failure do not respond to digitalis and theophyllin therapy, preparations of salts of mercury may cause a diuresis and complete relief. The mercury salts vary in content and are said to contain 33.9, 39.6, and 41.1 per cent of mercury. Some preparations have a maximum and minimum percentage prescribed: "not less than 38.0 per cent nor more than 41.0 per cent when calculated to the dried substance." Intravenous administration may produce a diuresis the amount of which will vary with the fluid intake. The repeated use of the preparation at short intervals may be associated with a decreasing output. A rest period of several days may be followed by another period of large output succeeded by a day-to-day decreasing output. Any one of the mercury preparations responds in this way—the relation of the size of the dose, or the mercury content to this variable output is not clear. It does not appear to be a response regularly proportionate to the mercury percentage of the preparation administered. One-half c.c. at one period may cause as profuse a diuresis as 2 c.c. of the same preparation. Elements of irritation, stimulation, and fatigue are apparently uncertain variables.

Trans-Thoracic Electrocardiography; Clinical Use of the 9-Lead Hook-Up. (Lantern Slides.) Albert S. Hyman, M.D.

ABSTRACT

The conventional three-lead method of electrocardiographic study fails to reveal cardiovascular pathology in 18 per cent of cases which post-mortem show extensive disease. The explanation lies in the fact that the original electrodynamic triangle of Einthoven conceives the heart in situ as a triangular plane. Lesions outside this mathematical formula fail to register. The original work of Waller with his 16 leads is reviewed. The heart is conceived as a solid organ represented as a triangular plane turned on a vertical axis and thus producing a cone. The 9 divisions of the electrodynamic cone and their electrical mathematical formulae. The clinical use of the trans-thoracic leads. Description of the leads and the electrodynamic segments of the cone displayed. Demonstration of the 9-lead electrocardiographic hook-up. Normal records from birth to old age. Clinical histories of patients with un-

questioned cardiovascular disease but with normal three conventional lead electrocardiograms. Reexamination of these same cases by the 9-lead hook-up. The Witkin formula for the localization of coronary infarcts, with illustrative cases showing 9-lead records and post-mortem specimens. Statistical data in regard to prognosis from localization.

Convalescent Care of the Cardiac Child. Alexander T. Martin, M.D.

ABSTRACT

Analysis of 963 cardiac children ranging from six to sixteen years at three convalescent homes (Martine Farm, Reed Farm, and Nichols Cottage) near New York City. Study covers thirteen years and comprises 1,279 visits. Children were drawn from 54 institutions or agencies in Greater New York. Two hundred fifty-three or 26.2 per cent of these children have died, death being due in the majority of cases to a reactivation of the rheumatic state with carditis. Seven hundred and ten or 73.8 per cent are living. Average stay 152 days. Average gain in weight 6.1 pounds. Etiological study shows 74.5 per cent to have had rheumatism. This includes polyarthritis and chorea. Congenital heart disease 3.5 per cent. Cases studied are Groups IIA and IIB. Return visits show an increasing number in the IIB group. Value of tonsillectomy inconclusive. Active follow-up maintained in the 710 living children, 45.4 per cent through cardiac clinics and 19.1 per cent through correspondence and home visits. Of the latter group 53.5 per cent under no medical supervision. Of 18 girls married, 5 have no children, 11 have one child, and 2 have two children. One of these died following cesarean section. Figures on incidence of rheumatic reactivation following return from the convalescent home are not conclusive because reliable criteria are not available in most cases.

The Two-Step Test of Myocardial Function. Arthur M. Master, M.D. To be published.

Ergotamine Tartrate in Paroxysmal Auricular Tachycardia. Charles J. Oppenheim, M.D.

ABSTRACT

The various methods generally employed to secure an abatement of attacks of this troublesome condition indicate how ineffectual any one method has proved to be. Based upon the experimental studies showing that ergotamine tartrate has a depressing effect upon both augmentor and inhibitor sympathetic fibers, and tends to produce marked slowing of the heart rate, it has been given to patients during attacks, hypodermatically in doses of 0.0005 gm. In one case it was possible to obtain electrocardiograms during and immediately following cessation of the attack. In practically all cases cessation of the attack has been striking, prompt, and without apparent ill effect. It would appear that ergotamine tartrate is a valuable drug in the treatment of attacks of paroxysmal tachycardia.

The Size of the Angle of Clearance of the Left Ventricle as a Criterion of Ventricular Enlargement. May G. Wilson, M.D.

ABSTRACT

Roentgenographic observations of 504 children between the ages of five and fifteen years were made. The series included normal children and subjects with possible, potential, and organic heart disease. Teleoradioscopy at a distance of two meters and fluoroscopic examination in the three standard positions, namely, posterior

anterior, left anterior, and right anterior oblique was made on each subject. Standard degrees of rotation were used in the oblique positions. This is a simple, reasonably accurate roentgenographic method for recognizing cardiac abnormality in children. The *angle of clearance* of the *left ventricle* in the left anterior oblique position differentiated with the greatest degree of frequency the normal from the abnormal heart, compared with measurements of the frontal plane of the cardiac silhouette. A normal *angle of clearance* of the left ventricle (of less than 55 degrees) in the left anterior oblique position would seem to be a reliable radiological criterion.

The Effect of Continuous Infusions of Minute Doses of Epinephrine on the Blood Pressure, Urea Excretion and Urine Volume in Various Clinical Conditions Including Bright's Disease. Charles A. Poindexter, M.D., and Herman O. Mosenthal, M.D.

ABSTRACT

Richards observed that minute doses of epinephrine brought about a constriction of the efferent vessel of the glomerulus and a dilation of the afferent vessel and resulted in a definite increase in urinary secretion (frog). This observation was the stimulus for this experimental work because it was thought that its application might be of value in the treatment of uremia. By means of a Woodyatt continuous infusion apparatus epinephrine was given intravenously in doses of approximately 0.0005 mg. per kilogram per minute. In two moribund patients with low arterial tension the injection of epinephrine resulted in an elevation of the blood pressure which was directly proportional to the dose of epinephrine and which was maintained during the period of the infusion. In patients with a normal or an initial elevated blood pressure (Bright's disease) there is no notable rise of blood pressure with the amounts of epinephrine employed. The urea concentration in the urine usually increased during the period of injection. The urine volume usually increased both during and several hours following the continuous infusion of epinephrine. No harmful effects were observed in any of the patients.

The Action of Quinine and Quinidine on Patients With Transient Ventricular Fibrillation. Sidney P. Schwartz, M.D., and Abraham Jezer, M.D. (See AMERICAN HEART J. 9: 792, 1934.)

Studies on Transient Ventricular Fibrillation. IV. The Post-Fibrillatory Period: A Definite Clinical Entity. Sidney P. Schwartz, M.D., and Abraham Jezer, M.D.

ABSTRACT

Clinical and electrocardiographic studies were carried out on four patients with auriculoventricular dissociation subject to transient seizures of ventricular fibrillation. Many observations have revealed that the period immediately following a seizure of syncope due to transient ventricular fibrillation is of a definite pattern. When fibrillation of the ventricles ceases, the recovery process to normal is characterized by a progressive increase of the idioventricular rate from 6-12 beats per minute to as high as 160 beats per minute before there is a return to the basic rhythm. This is characteristic of syncopal seizures associated only with transient ventricular fibrillation. In all other types of syncopal seizures, such as those associated with standstill of the ventricles, the return to normal rhythm is totally different. The existence of transient ventricular fibrillation as responsible for a syncopal seizure may be suspected in a patient if, following the period of syncope, the ventricular rate is found to have increased far above that of the basic level.

Department of Reviews and Abstracts

Selected Abstracts

Sager, Robert V., and Sohval, Arthur S.: Combined Syphilitic and Rheumatic Disease of the Aortic Valve. Arch. Path. **17:** 729, 1934.

Three cases of combined syphilitic and rheumatic disease of the aortic valve are reported. In the presence of commissural syphilis, sclerotic deformities of the aortic valve usually occur. When rheumatic lesions are found elsewhere in the heart, it is at times impossible to decide from macroscopic examination alone whether rheumatic disease participated in the production of the aortic valvular defect. By the aid of established histologic criteria for the recognition of rheumatic and syphilitic disease of the aortic valve it is possible to demonstrate such participation, if it exists. Emphasis is placed on the limitation of syphilitic changes in the aortic leaflets to their commissural extremities in the great majority of cases and on the diffuse nature of the characteristic lesions of rheumatic valvulitis. Interstitial valvulitis in the midportion of an aortic cusp, particularly with fibroelastic vascularized reduplications on the ventricular aspect, usually signifies disease other than syphilis (nearly always a rheumatic infection). Association of these two types of histopathological lesions establishes the existence of combined syphilitic and rheumatic disease in the aortic valve. The rarity of this association is indicated by the fact that it has, to the author's knowledge, never been previously reported.

McGinn, Sylvester, and White, Paul D.: Clinical Observations on Aortic Stenosis. Am. J. M. Sc. **188:** 1, 1934.

A study of arotic stenosis is presented based on 123 cases proved at postmortem examination among 6,800 necropsies of patients with all types of disease at the Massachusetts General Hospital and 113 clinical cases among 4,800 patients studied in cardiovascular consultation practice. In the post mortem series 71 per cent of the patients were males and in the clinical series 63 per cent.

Aortic stenosis occurred in the postmortem series almost as often as did mitral stenosis. The lower incidence in the clinical series may be due in part to the fact that it is difficult or impossible clinically to diagnose aortic stenosis if the stenosis is but slight in degree. Closer search for the lesion resulted in the finding clinically of twice as many cases of aortic stenosis, definite or questionable, in the second half of the clinical series as in the first half. It appears justifiable to make the clinical diagnosis of aortic stenosis when a loud harsh systolic murmur is heard in the region of the second right intercostal space and is transmitted to the neck, in the absence of pronounced aortic dilatation due to luetic aortitis or marked hypertension, especially when there is evidence of other valvular deformity or a history of rheumatic infection. An aortic systolic thrill, a diminished or absent second aortic sound, a plateau pulse, and an aortic diastolic murmur are important confirmatory findings; but it is not necessary to await the presence of all these signs before making the diagnosis. If one waits for all these signs, a large majority of cases of aortic stenosis often of considerable clinical importance would be missed.

A comparison has been made in the postmortem series, of cases showing calcareous changes in the stenosed aortic valve with cases showing no calcareous change in the valve. Calcareous valvular changes were found more frequently than noncalcareous (86 to 37) with males predominating and living past middle life in the calcareous group while the sexes were evenly distributed in the noncalcareous group, few of whom lived longer than fifty years. Angina pectoris, cardiac asthma and higher blood pressures were more frequently found in the calcareous group, while a positive rheumatic history and auricular fibrillation were more frequent in the noncalcareous group. The average pulse pressures were approximately the same. The heart weights were similar in the two groups, but calcareous changes in the mitral valve, aorta and coronary arteries were much more common, as would be expected, in the older, calcareous group. The presence or absence of calcareous changes in the arotic cusps is clinically relatively unimportant as compared to the aortic stenosis itself, excepting as it alters the degree of stenosis or aids in the roentgen ray diagnosis.

A comparison of the autopsied cases having aortic stenosis alone with those having aortic stenosis combined with mitral stenosis showed males to be represented equally in both groups; females, however, were three times more frequent in the combined than in the isolated group. Mitral stenosis was found much more often in the patients dying under fifty years, while aortic stenosis alone occurred most commonly in people beyond that age. Angina pectoris was found more often in patients with aortic stenosis alone (14 to 2), while auricular fibrillation occurred much more often in cases with complicating mitral stenosis (26 to 13). The average heart weights were approximately the same for the two groups (612 gm. and 592 gm.). Coronary sclerosis and aortic sclerosis were more common in cases of aortic stenosis alone; sclerotic changes in the mitral valve were found in 23 of the 50 cases with complicating mitral stenosis.

In three groups of patients of the postmortem series having various degrees of calcareous aortic stenosis, it was found that the correct diagnosis had not been made clinically in any having only moderate calcareous changes, mostly at the base of the aortic cusps, and that the symptoms of congestive failure were less frequent in this group than in those instances where the lesion was more marked. At least a few of the cases showing only moderate aortic stenosis should have been diagnosed correctly antemortem if proper attention had been directed to the signs that were present. The patients with pronounced aortic insufficiency in addition to aortic stenosis had a shorter terminal illness and died at a younger age than did the patients in whom stenosis of the valve predominated. The average weight of the hearts in the group with pronounced aortic insufficiency was also higher, the smallest hearts being found in those cases with little or no aortic insufficiency and with only a moderate amount of stenosis.

It is evident from this analysis that all grades of aortic stenosis exist, much as in the case of mitral stenosis; that aortic stenosis even of considerable degree is common, particularly in males; that it is doubtless often caused by infection, especially rheumatism; that calcareous changes are found chiefly in the older patients, no matter what the cause; that aortic stenosis is less serious than aortic regurgitation of high degree, being found in many old patients after years of valvular disease; that it is sometimes associated with considerable hypertension; that, as in the case of mitral stenosis, the symptoms and signs vary in number and degree with the extent of the aortic stenosis; that aortic stenosis is often overlooked when it should be clinically diagnosed; and that it is an important lesion to search for, even in the lesser grades because of the progression of the lesion and of the frequency with which it is associated with congestive heart failure.

Greenspan, Edward B.: Carcinomatous Endarteritis of the Pulmonary Vessels Resulting in Failure of the Right Ventricle. Arch. Int. Med. **54**: 625, 1934.

Four cases of carcinomatous lymphangitis are reported, three secondary to scirrhous adenocarcinoma of the stomach and one to adenocarcinoma of the sigmoid. The cases presented all or part of the pulmonary symptoms of cough, shortness of breath, and cyanosis with inconspicuous physical signs in the lungs. The three cases secondary to scirrhous carcinoma of the stomach presented diffuse obliterative endarteritis of many pulmonary arterioles and small arteries. The widespread obliterative endarteritis of the lung was due chiefly to the influence of the carcinomatous lymphangitis of the neighboring perivascular lymphatics, rarely to carcinoma cell emboli. In two of the cases, right ventricular cardiac failure was the direct result of the diffuse obliterative endarteritis of the pulmonary vessels.

In cases of right ventricular cardiac failure presenting no significant pulmonary or cardiac findings, the possibility of a diffuse secondary carcinomatous lymphangitis of the lungs with accompanying obliterative endarteritis of the pulmonary vessels should be considered.

Craig, Winchell McK., and Brown, George E.: Unilateral and Bilateral Resection of the Major and Minor Splanchnic Nerves. Arch. Int. Med. **54**: 577, 1934.

Five patients with essential hypertension of varying degrees of severity have been subjected to unilateral or bilateral resection of the splanchnic nerves and to removal of the first lumbar ganglion. In two subjects, significant quantitative reduction of the pressor reactions to cold resulted. In one subject, subjective and objective improvement was striking. In the most severe forms of essential hypertension, with early renal involvement and advanced organic changes in the arterioles, the effects on the blood pressure have not been striking. Resection of the splanchnic nerves is a relatively safe operation and carries small risk. No untoward effects have been noted. Further application of this surgical procedure is justifiable in the early stages of the severe progressive form of essential hypertension in young persons.

Bellet, Samuel, Johnston, Charles G., and Schecter, A.: Effect of Cardiac Infarction on the Tolerance of Dogs to Digitalis. Arch. Int. Med. **54**: 509, 1934.

Tolerance of dogs to digitalis was determined at various intervals of time after ligation of the coronary artery: one-half hour after ligation of the coronary artery; four days later, during the stage of acute and subacute infarction; and from six weeks to six months later, during the stage of chronic infarction. The tolerance of these animals was compared with that of animals in a normal control series.

Dogs standardized within one-half hour after ligation showed no diminution in tolerance to digitalis as compared with those in a control group. During the stage from acute to subacute infarction, there was a diminished tolerance to digitalis which averaged from 20 to 30 per cent below the average of the figures for the normal controls. In the animals with chronic infarction in which the area of infarction was considerably smaller than in the acute or subacute stage, standardized from six weeks to six months after ligation of the coronary artery, the tolerance was less than that of the normal animals but higher than that of the group with the subacute infarctions.

The diminution in tolerance after ligation of the coronary artery apparently depends on the presence of infarction and probably also on the extent and stage of the infarcted area. These findings lend support to the clinical impression that

digitalis in massive doses may be dangerous during the stage of subacute and chronic infarction and that it should be used with caution in such cases.

Lombardini, R. Velasco, and Duomarco, J.: The Technic of Exteriorization and Suspension of the Heart in the Dog. Rev. Argentina de Card. **1**: 138, 1934.

A comparatively simple procedure is described to lead the action current of the heart from different extents of cardiac surface. If a dog under anesthesia is prepared in such a way as to have the heart in a hanging position, the latter can be immersed to any desired degree in a glass filled with saline solution. The action current of the heart may now be led off by two electrodes, one of them placed on the back of the animal and the other plunging in the same glass as the heart.

Using this procedure it was found that as the surface of the heart in contact with the liquid increases, the electrical variations recorded become smaller. This fact may explain the low voltage of the deflections recorded in pericardial effusion: the liquid around the heart establishes a sort of short circuit to the heart currents, and the galvanometer is not influenced by the total electrical variations.

In order to lead off the heart currents, the heart must be surrounded by elements of unequal resistance, the electrical variations following the path of the lower resistance, probably through the base of the heart and perhaps also through the part of the heart laying on the diaphragm. This might be of importance to decide the type of ventricular preponderance shown by the electrocardiogram.

Battro A., Menendez, E. Braun, and Orias, O.: Gallop Rhythm. Rev. Argentina de Card. **1**: 117, 1934.

Twenty-two cases of clearly audible gallop rhythm were graphically analyzed by simultaneously recording the heart sounds and the venous pulse. In three cases the extra sound occurred during the final moments of the rapid inflow phase; in four cases the extra sound occurred during auricular contraction; in the remaining cases, the extra sound occupied a position which was coincident with both these moments, brought closer together by the increased heart rate. In the cases corresponding to the latter group, two alternatives happened: in some cases a brief interval could be observed between the two sounds; in others, on account of a perfect coincidence of both moments, there was only one sound.

Phonocardiograms taken from normal persons often show sound vibrations during the latter part of the rapid diastolic inflow (the so-called third physiological heart sound) and also, occasionally, during auricular systole (auricular physiological sound). On account of their properties, these sounds are easier to record (if adequate devices are used) than to be heard by simple auscultation.

The conclusion may be drawn that gallop rhythm results from the pathological exaggeration of phenomena hardly audible, which, however, can be more or less easily recorded in many normal individuals.

According to their mechanism of production, the following nomenclature is suggested: rapid inflow gallop, presystolic gallop and summation gallop. Summation may be either complete or incomplete.

It is impossible by simple auscultation, to ascribe any case of gallop rhythm to any particular type. The occurrence of the extra sound during the beginning, middle or end of diastole does not necessarily imply that the gallop is one of rapid inflow, summation, or presystolic, respectively. It is the graphic analysis by means of the phonocardiogram and the phlebogram optically recorded which will precisely determine the type of gallop concerned in each particular case.

Menendez, E. Braun, and Orias, O.: Phonocardiographic Studies in the Young Adult Heart. Rev. Argentina de Card. **1:** 101, 1934.

By optically recording the heart sounds, it is possible to recognize normal acoustic phenomena which are not easily heard by simple auscultation. The third normal heart sound was neatly recognizable in 42 out of 100 phonocardiograms recorded in as many healthy medical students from twenty to twenty-five years old. Small vibrations, considered as a vestigial third heart sound, were plainly visible in 18 other records. An evident auricular sound was recorded in 15 cases, and in 5 other instances there were clear vestiges of it.

The third heart sound invariably occurs during the last moments of the ventricular inflow phase. The physiological auricular sound starts about 0.04 second after the beginning of the auricular systole.

It is probable that both, third heart sound and physiological auricular sound, have a similar mechanism of production; they might be due to the vibrations set up in the ventricular wall by the sudden inrush of the blood coming from the auricles.

Castro, Olyntho de: Partial Flutter and Fibrillation. Arq. brasil. de cardial. e hemat. **1:** 129, 1934.

The author suggests the term "partial flutter and fibrillation" for those cases in which tracings show an imperfect function of auricular contraction. He believes that the cause of these modifications is a partial affection of the auricular myocardium, i.e., there are certain groups of fibers which have been affected by the process resulting in flutter or fibrillation. The persistence of the P-wave although more or less altered is explained on the basis of the marked contraction of the majority of the sound fibers which give a normal sinus rhythm.

Marble, Alexander; Field, Madeleine E.; Drinker, Cecil K.; and Smith, Rachel M.: The Permeability of the Blood Capillaries to Lipoids. Am. J. Physiol. **109:** 467, 1934.

The peripheral (cervical) lymph of normal fasting dogs contained on the average per 100 c.c. of lymph the following: cholesterol, 56 mg.; fatty acid, 239 mg.; and total lipid, 305 mg. These values are respectively 41 per cent, 54 per cent, and 52 per cent of those for cholesterol, fatty acid, and total lipid in blood plasma from the same dogs. Blood and lymph samples were obtained as nearly simultaneously as possible.

Following the intravenous injection of fat-laden chyle or of a fat emulsion, there usually occurred within one to four hours a slight rise in the total lipid content of the cervical lymph. Under such conditions no significant change occurred in the cholesterol content of the lymph despite the production at times of a mild hypercholesterinemia.

These experiments suggest that the degree of permeability of the blood capillary wall to lipoid substances other than cholesterol is slight but definite and is greater than that to cholesterol itself.

Himwich, H. E., Goldfarb, W., and Nahum, L. H.: Changes of the Carbohydrate Metabolism of the Heart Following Coronary Occlusion. Am. J. Physiol. **109:** 403, 1934.

Observations were made on 34 dogs during experimental coronary occlusion. The infarcted area lost appreciable quantities of its glycogen which appeared in part as increased amounts of soluble carbohydrates and lactic acid. In most cases before occlusion, the heart removed lactic acid from the blood stream. After

the coronary artery was ligated the heart usually added lactic acid to the blood stream. The increased lactic acid production by the heart was probably due to a diminution of the O_2 supplied to the cardiac tissues. Glucose was absorbed from the blood both before and after the coronary occlusion. It is suggested that the accumulation of metabolites in the infarcted areas may be related to the subjective pain experienced during coronary occlusion.

Riseman, Joseph E. F., and Stern, Beatrice: A Standardized Exercise Tolerance Test for Patients With Angina Pectoris on Exertion. Am. J. M. Sc. 188: 646; 1934.

A simple and safe standardized exercise tolerance test is described for use in patients with angina pectoris. The results in a group of 57 consecutive patients with the clinical diagnosis of angina pectoris are presented. Exercise performed under the standardized conditions of the test induced attacks in 34 patients. These attacks were precisely like those experienced in daily life. When the standardized test was repeated, even months later, the same amount of exercise again precipitated an attack in the same individual.

Nineteen patients did not develop an attack under the standardized conditions. The diagnosis of angina pectoris eventually proved to be exceedingly doubtful in all but one of these patients.

Objective evidence is presented illustrating the influence of various environmental factors on the amount of exercise necessary to precipitate attacks of angina pectoris in patients with this condition.

The test affords a means of investigating angina pectoris and is of distinct value as an aid in diagnosing doubtful cases and in evaluating both the condition of the patient and the results of therapy.

Flaxman, Nathan: Heart Disease in the Middle West. Am. J. M. Sc. 188: 639, 1934.

The incidence of organic heart disease in the Cook County Hospital, Chicago, for the period from January 1, 1932, to June 30, 1933, was 1.7 per cent of the total hospital admissions and 7.2 per cent of the medical admissions. Of the 1,646 patients, 38 per cent died in the hospital during the stated period. This was 6.7 per cent of the hospital deaths and 14.4 per cent of the medical deaths.

In this study the common age for heart disease was the forty to sixty year period. It occurred most frequently in the sixth decade in the white patients and in the fifth decade in the colored patients. Hypertension was the most common cause of organic heart disease regardless of race or sex. Arteriosclerotic and rheumatic heart disease were more common in the white patients. Syphilitic and hypertensive heart disease were more common in the colored patients. Arteriosclerotic heart disease was five times more common in the white patients. Pulmonary emphysema as a cause of myocardial insufficiency was practically confined to white males.

The author comments that statistics on the incidence and etiology of heart disease must be classified on a better basis, the most representative statistics being based on large general hospital admissions. This comment is open to serious question, since an extremely large group of cardiac patients never find their way into hospitals, and such a group would be entirely exclusive from any statistical analysis.

Ruddock, John C.: Dilatation of the Left Auricle to the Right. Radiology 23: 397, 1934.

The author concludes from examination of cardiac roentgenograms, together with histories and postmortem examination of the hearts, that dilatation of the right side of the heart as shown and demonstrated by roentgenographic examination in compensated cases of mitral stenosis is due to enlargement of the left auricle. He believes that as the auricle enlarges and dilates, there is an encroachment posteriorly to the right side so that the left auricle enters into the formation of the right cardiac silhouette. Enlargement of the right side of the heart in decompensated cases as shown by roentgenographic examination is due to dilatation of the right auricle.

In roentgenograms of cases of mitral stenosis, the cardiohepatic angle is either acute or obtuse and is in direct proportion to the degree of decompensation. In cases in which compensation is complete, the dilatation of the left auricle causes an acute angle which will be shown by roentgenograms as the cardiohepatic angle. In cases in which there is a decompensation and a resulting dilatation of the right auricle, the angle is either right or obtuse.

Description of the roentgenograms should call attention to the cardiohepatic angle, and the presence of compensation or decompensation must be known before a correct interpretation of the heart contour can be made.

Hansen, Olga S., and Maly, Henry W.: The Heart After Phrenic Nerve Interruption. Am. Rev. Tuberc. 30: 527, 1934.

In an effort to evaluate the effects of unilateral diaphragmatic paralysis by phrenic nerve interruption and the associated intrathoracic changes upon the heart, 100 successive cases have had physical, electrocardiographic and x-ray observations before and after this operation at Glen Lake Sanatorium for tuberculosis. No other type of collapse therapy had been employed. Those with pleural effusion were discarded.

Electrocardiograms showed a change in the direction and amplitude of the QRS waves in sixty-five, slight in degree in all but ten (fifty-five), but enough to indicate a shift of the electrical axis toward the left in twenty-five (all but one after a left-sided operation), and toward the right in ten (all but one after a right-sided operation). P-waves changed only six times, and no evidence of auriculoventricular conduction delay appeared. T-wave changes appeared in twenty-three cases, ten times with an increased negativity in the significant leads, and thirteen with an increase of size or a decrease of negativity. No clinical or roentgenographic evidence of myocardial changes appeared, or of defective conduction through the ventricles.

The heart position was displaced from its preoperative position in sixty-nine cases. After right-sided operations there was a preponderance of shifting toward the left or healthy side (twenty-nine times out of thirty-seven). After left-sided operations the heart might be displaced to either side (fifteen toward the left and seventeen toward the right). Twice as many were displaced away from the collapsed side as toward it (forty-six and twenty-three). Comparing the direction of the deviation of the electrical axis with that of heart displacement revealed agreement in eleven and disagreement in twenty-three.

No evidence of heart damage or disturbance of function appeared.

Cohn, Alfred E., and Steele, J. Murray: Unexplained Fever in Heart Failure. J. Clin. Investigation 13: 853, 1934.

Observations of the behavior of certain cardiac patients with fever have brought into question the wisdom of assuming in instances of unexplained fever

the presence of an infectious process. For this reason, the records of 368 cardiac patients have been studied. Of 172 who presented symptoms or signs of heart failure, 153 exhibited on two or more occasions, elevation of the rectal temperature to at least 100° F. Usually the elevations were clearly associated with conditions generally recognized as accompanied by fever, but in 49 cases the occurrence of fever was without satisfactory explanation. In certain ones its development suggested an origin, at least in part, dependent upon heart failure itself.

It is pointed out that fever may occur during heart failure in the absence of evidence of infection or of the noninfectious conditions which have been enumerated and which are likewise associated with the development of fever. Results of bacteriological studies of material obtained by puncture of the lungs during life and from the lungs at autopsy in patients with heart failure accompanied by fever are presented. In a number of cases, signs of heart failure appear or begin to increase just prior to the occurrence of fever. Fever and the signs of heart failure disappear simultaneously. These relations suggest that the occurrence of fever in these instances is dependent upon mechanisms involved in heart failure itself.

Steele, J. Murray: Fever in Heart Failure. Relations Between the Temperatures of the Interior and the Surface of the Body. J. Clin. Investigation 13: 869, 1934.

Daily fluctuation of surface and rectal temperatures has been studied in normal individuals, in individuals during and after recovery from heart failure, and in a few individuals suffering from infectious diseases. The patients with heart failure were selected for study because they exhibited fever and because evidence of infection was sought but was not found. A fairly regular normal diurnal variation in the temperature of the extremities opposite in direction to that of the rectal temperature is described. The behavior of the temperature of the surface of the body, especially of the extremities, in the cases of heart failure which exhibit fever of unexplained source is different from that observed in patients with fever associated with infectious diseases. The temperature of the surface in cardiac patients is lower than that of normal individuals, while that of patients with infectious fever is as high as or higher than normal. The difference in behavior leads to the conclusion that elevation of rectal temperature in cases of heart failure need not be of infectious origin but may depend upon a variety of processes incident to heart failure itself.

Steele, J. Murray, and Kirk, Esben: The Significance of the Vessels of the Skin in Essential Hypertension. J. Clin. Investigation 13: 895, 1934.

The temperature of the skin of individuals suffering from arterial hypertension does not differ significantly from that of normal individuals. Diurnal variations in surface temperature regularly occur in individuals with arterial hypertension without significant change in arterial pressure. Elevation of arterial pressure in hypertensive individuals does not depend on, though it may be accompanied by, constriction of the arterioles of the skin.

Page, Irvine H.: The Effect of Renal Efficiency of Lowering Arterial Blood Pressure in Cases of Essential Hypertension and Nephritis. J. Clin. Investigation 13: 909, 1934.

The efficiency of the kidneys, as measured by the urea clearance test, is not altered by a marked fall in arterial blood pressure occurring spontaneously or

induced by sodium thiocyanate administered by mouth, or colloidal sulphur administered intramuscularly, in patients suffering from essential hypertension. Sodium thiocyanate or colloidal sulphur in the dosage employed and over short periods of time does not appear to have a detrimental action on the kidneys of patients suffering from essential hypertension.

Fall in arterial blood pressure occurring spontaneously or as the result of renal denervation in patients suffering from chronic Bright's disease also caused no change in renal efficiency. The abnormal elevation of blood pressure in these cases does not appear to assist in maintenance of renal efficiency. This evidence does not support the compensatory theory of the cause of hypertension in patients suffering from nephritis or essential hypertension.

Kountz, W. B., Pearson, E. F., and Koenig, K. F.: Observations on the Effect of Vagus and Sympathetic Stimulation of the Coronary Flow of the Revived Human Heart. J. Clin. Investigation **13**: 1065, 1934.

The effect of vagus and sympathetic nerve stimulation on coronary flow was studied in the revived human hearts and in the same hearts arrested by alkaline and acid perfusate. In the normal beating human heart, vagus stimulation slowed the heart rate and increased the coronary flow. Sympathetic nerve stimulation increased the heart rate and slowed the coronary flow.

In hearts in which there was dissociation of auricular and ventricular contraction and in which the rate was not influenced by the nerves, vagus stimulation slowed the coronary flow, while sympathetic stimulation increased it.

In hearts arrested with increased tone, vagus stimulation increased the coronary flow while sympathetic stimulation in two cases decreased it. In hearts arrested in decreased tone by acid perfusate, vagus stimulation had no effect, while sympathetic stimulation increased the flow.

The action of the nerves in these hearts was compared to that of drugs. It was found that drugs which in the beating heart increased muscle action and decreased coronary flow closely simulated the action of the sympathetic; while drugs which dilated the beating heart and increased coronary flow simulated vagus nerve stimulation. No such similarity was noted between nerve action and drugs which act primarily as vasoconstrictors or vasodilators of the coronary vessels themselves.

The results of this group of experiments suggest that in man the cardiac nerves exert their most important action on coronary flow through changes in the state of the heart muscle.

Donal, John S.; Gamble, Clarence J.; and Shaw, Robert: The Cardiac Output in Man. Am. J. Physiol. **109**: 666, 1934.

The katharometer has been adapted to the measurements of ethyl iodide in air required by the procedure of Starr and Gamble for determining the cardiac output in man. The average error of a determination of the relative concentration of ethyl iodide in the range in question is ±0.04 mg. per liter or ±0.0006 per cent by volume.

The instrument permits a marked saving in the operator's time required. A duplicate determination of cardiac output including the analyses and calculation of results may be made in seventy minutes. Cardiac outputs in the lying, sitting, standing, and inverted positions have been compared in fasting subjects at rest. The average value in the sitting position was 87 per cent and in the standing position 82 per cent of that when lying. The corresponding values for the output per beat were 76 and 60 per cent. In all the cases the arteriovenous oxygen

difference was greater in the erect than in the horizontal position. In the vertical position with the head down, the cardiac output per minute and per beat was less and the arteriovenous oxygen difference greater than when the subject was horizontal.

Comparisons are given of other circulatory and respiratory values in the various positions.

Proger, S. H., and Dexter, L.: The Continuous Measurement of the Velocity of Venous Blood Flow in the Arm During Exercise and Change of Posture. Am. J. Physiol. **109**: 688, 1934.

The method recently described by Gibbs has been found useful and practicable as a means of measuring continuously the relative velocity of blood flow and in certain instances qualitative changes in volume flow. In cases in which it is desired to record changes in velocity in a vessel which is visible, a solid needle in which hot and cold thermo-junctions have been incorporated has certain advantages over an open needle into which the thin wires containing the junctions are threaded after venipuncture.

The velocity of blood flow in the superficial and deep veins of the arm behave antagonistically with exercise of that arm, the flow in the deeper veins becoming more rapid and in the superficial veins slower than at rest. With moderately severe exercise involving chiefly the lower extremities (pedalling on a stationary bicycle), there is no change in the velocity of blood flow in the veins of the upper extremities. In the superficial and deep veins of the upper extremities, the velocity of blood flow is slower with the arm held in the erect position and more rapid with the arm hanging down, than when the arm is in the horizontal position.

Padilla, T., and Cossio, P.: Prognosis in Myocardial Infarcts. Rev. Argentina de Card. **1**: 181, 1934.

Mortality in this series of cases has been 38 per cent, which is somewhat lower than that of other observers. A great majority of deaths occurred during the first month following the attack. Nineteen per cent of the patients died within forty-eight hours, and 14 per cent died between that period and the end of the month. Within the first twenty-four hours, death occurred suddenly and probably was due to ventricular fibrillation; rupture of the heart was exceptional.

After fifteen days from the beginning of the attack and within the first year, death was due to cardiac insufficiency; embolism was exceptional. After one year, death may be caused by a new cardiac infarct or by any other arterial accident.

After one month from the beginning of the attack, 27 per cent of the cases were clinically cured and 35 per cent were so after a six months' period. Six months after the attack, slight symptoms persisted in 17 per cent of the cases. In 9 per cent, congestive heart failure could be observed, and 5 per cent suffered from angina pectoris. Death occurred in 60 per cent of the patients suffering from a second attack of infarction.

Sex and age made no difference so far as prognosis is concerned. The absence of pain has severe prognostic significance. Intense pain was present in a large proportion among the patients who survived, 72 per cent, than among those who died. The absence of circulatory collapse has a favorable prognostic significance. The early appearance of cardiac failure, the appearance of an indefinite discomfort sensation with or without precordial oppression and the absence of electrocardiographic disturbance have a severe prognostic significance. Electrocardiograms of the apex type (T_1) or the base type (T_3) have no particular prog-

nostic significance. If both types occur at the same time, prognosis becomes severe. Disturbances of rhythm, other than isolated extrasystoles, have an unfavorable prognostic significance.

Battro, Antonio, and Del Rio, Julio G.: Lead IV in Electrocardiography. Rev. Argentina de Card. **1**: 192, 1934.

Systematic use of Lead IV has led to the following conclusions:

Lead IV should be recorded in all anginal syndromes: in four out of twenty patients with angina, there was definite electrocardiographic evidence of myocardial infarction in Lead IV, while the conventional leads were practically normal. Lead IV has also proved of value in determining complexes which are not far from normal in the conventional leads but which are true extrasystoles in Lead IV. Lead IV, however, does not allow a clear distinction between right and left ventricular extrasystoles. Right bundle-branch block showed a concordant positivity of the main initial deflections in Lead IV and Lead I. Conversely, left bundle-branch block showed a concordant negativity of the main initial deflections in the same leads.

Rivolta, L. A.: Radiograms of the Heart in Systole and Diastole. Rev. Argentina de Card. **1**: 216, 1934.

A device is described to obtain radiographs of the heart during either systole or diastole. The electrical disturbance caused by the heart sounds are amplified in a microphone adapted to the precordial region, starts the x-ray machine. Mechanisms are provided which allow an accurate adjustment so as to take the radiograph at any desired moment after the beginning of cardiac activity during either systole or diastole. When the heart sounds are modified in their number or quality, the central arterial pulse can be substituted to start the x-ray machine.

A characteristic feature of this method consists in the actual mechanism of starting the x-rays which is very closely associated with cardiac activity (heart sounds or central pulse) thus avoiding the several causes of error that are encountered in following other procedures so far described.

Paul, John R.; Harrison, Elizabeth R.; Salinger, R.; and DeForest, G. K.: The Social Incidence of Rheumatic Heart Disease. Am. J. M. Sc. **188**: 301, 1934.

In an attempt to determine the influence which poverty and urban environments may play as predisposing factors in rheumatic fever, the incidence of rheumatic heart disease has been determined in groups of children between the ages of five and eighteen years, attending urban and suburban schools in and about the city of New Haven.

Data from the routine examinations of 5,758 public school children performed by school physicians suggested that systolic murmurs, presumably of rheumatic origin, were roughly 1.5 times as prevalent among children from the poorer districts than in those from the better districts of the city.

From the authors' examination of 758 urban children, the incidence of rheumatic heart disease in a single large public school in one of the poorest districts of the city was found to be 48.1 per 1,000. This proved to be 1.5 times as high as that found in a public school in one of the better districts of the city, but 8 times as high as that found among a smaller group of pupils from urban private schools who came from the best districts of the city.

The average incidence of rheumatic heart disease among pupils attending two urban public schools was about twice that recorded among pupils of a similar age group who attended suburban and rural public schools.

Ernstene, A. Carlton; and Mulvey, Bert E.: A Study of Auricular Fibrillation Following Operations for Goiter. Am. J. M. Sc. 188: 382, 1934.

Sixteen of 213 patients with hyperthyroidism had auricular fibrillation during the preoperative period; while postoperative auricular fibrillation developed in 31 of the 197 who had normal rhythm before operation. The arrhythmia was present before operation in 2 of the 192 individuals who had adenomatous goiter without hyperthyroidism and developed after operation in 4 other patients in this group.

The age of the patient, type of goiter, and duration of hyperthyroidism appear to be the most important factors predisposing to the development of postoperative auricular fibrillation. The degree of elevation of the basal metabolic rate is of little significance. The immediate increase in the rate of metabolism following operation probably is the essential factor responsible for the initiation of the arrhythmia.

Postoperative auricular fibrillation is more common in thyrotoxic patients with adenomatous goiter than in those with hyperplastic goiter. This difference cannot be explained entirely by differences in the ages of individuals belonging to the two groups. The long duration of thyroid enlargement in the majority of patients with adenomatous goiter may favor the gradual development of myocardial damage, possibly as the result of repeated or prolonged periods of low grade, unrecognized hyperthyroidism.

Postoperative auricular fibrillation generally begins during the first sixty hours after operation. It rarely causes circulatory embarrassment, and normal rhythm usually is reestablished spontaneously within forty-eight hours.

Korey, Herman, and Katz, Louis N.: The Electrocardiographic Changes Produced by Injuries of Various Parts of the Ventricles. Am. J. M. Sc. 188: 387, 1934.

An analysis was made of the changes produced in the electrocardiogram during the first four hours following injection of 95 per cent alcohol into the dog's ventricular myocardium with the production of sharply demarcated areas of injury. Within a few minutes following injection of alcohol into the myocardium, monophasic ventricular complexes occurred several times. Deep inverted or tall upright peaked T-waves having rounded shoulders and symmetrical limbs—negative and positive coronary T-waves—were frequently found later. In addition to the T_1 and T_2 types of curves, two other types of change which we have called the T_p and T_n types occurred frequently. In the T_p type, positive coronary T-waves occurred in all three leads preceded by negative S-T deviations. In the T_n type negative coronary T-waves appear in all three leads preceded by positive S-T deviations.

On subdividing the ventricular myocardium into ten regions, it was found that the location of the myocardial lesion did not determine the magnitude of the electrocardiographic change, nor did it give rise to a characteristic Q-T type of change for any locality. It is concluded that using the standard three leads, the electrocardiogram cannot be used to differentiate between injury to the anterior and the posterior wall of the ventricles; between injury to the right and the left ventricle, and between injury to the apical and the basal portion of the ventricles. No constant correlation could be made between the size of the injured area and the magnitude of electrocardiographic change in the standard three leads. The electrocardiographic changes apparently do not depend upon the location of the injured area in relation to the endocardium or epicardium.

Book Reviews

VERHANDLUNGEN DER DEUTSCHEN GESELLSCHAFT FÜR KREISLAUFFORSCHUNG. VII TAGUNG. Edited by Professor Doctor Eb. Koch, Bad Nauheim. Theodor Steinkopff, Dresden and Leipzig, 1934, 326 pages.

The Transactions of the seventh (1934) annual session of the German Society for the Study of the Circulation maintain fully the high standards of those of the earlier meetings. The topics given special consideration are those of thrombosis and embolism. Most of the volume of more than three hundred pages is devoted to the various aspects, experimental, pathological, clinical, of these subjects; and the character of the presentations is indicated by the fact that among the many contributors are to be found such distinguished students of these conditions as Aschoff, Mosawitz and Dietrich.

L. A. C.

PRACTICAL TALKS ON HEART DISEASE. By George L. Carlisle, Associate Professor of Clinical Medicine, Baylor University, Dallas, Texas. Springfield, 1934, Charles C. Thomas, 153 pages.

This small book was written expressly for the general practitioner, and the author's purpose is manifest throughout. There are many features that should receive warm commendation; among these may be mentioned brevity, clarity, and refreshing sanity with respect to most of the subjects treated. The comments upon history taking, physical examination, and the interpretation of abnormal signs are pointed, emphatic, and thoroughly sound. His brief discussions of the four common etiological types of heart disease indicate his agreement with modern views, and are probably as satisfactory for the general practitioner as any very brief consideration of the subject could be.

There are, however, certain deficiencies that greatly lessen the value of the book, and it is unfortunate that the sections dealing with treatment are particularly inadequate or actually misleading. For example, the treatment of paroxysmal tachycardia and of auricular flutter is dismissed with a few words, and the most effective forms of treatment are not mentioned. The treatment of auricular fibrillation is discussed in a single sentence, which states that the only treatment is that of decompensation "because in treating decompensation, you are almost always treating auricular fibrillation." It is strange that a writer so obviously familiar with recent work in the field of heart disease should advise the regulation of digitalis dosage entirely on the basis of the heart's rate, and should make no distinction between cases of regular rhythm and of auricular fibrillation. His discussion of the treatment of angina and of coronary thrombosis is extremely misleading, and it is clear that he does not distinguish properly between the two conditions; for example, he treats anginal attacks with morphine, insists upon two months of complete bed rest, and says practically nothing about the future regulation of the patient's life, or of the use of nitrites. He has a number of excellent things to say about cardiac neuroses, but with respect to this subject also his advice about treatment seems quite superficial and unsatisfactory. It is deplorable that a book which displays

so much wisdom should summarize this important matter with the words: "The treatment of cardiac neurosis consists in out-talking the patient over a long period of time."

While these are serious defects, it would be unfair to leave the impression that the book fails entirely in its purpose. There is so much of value and importance that it is to be hoped the next edition will correct the relatively few omissions and errors.

H. M. M.